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CASSIER'S MAGAZINE

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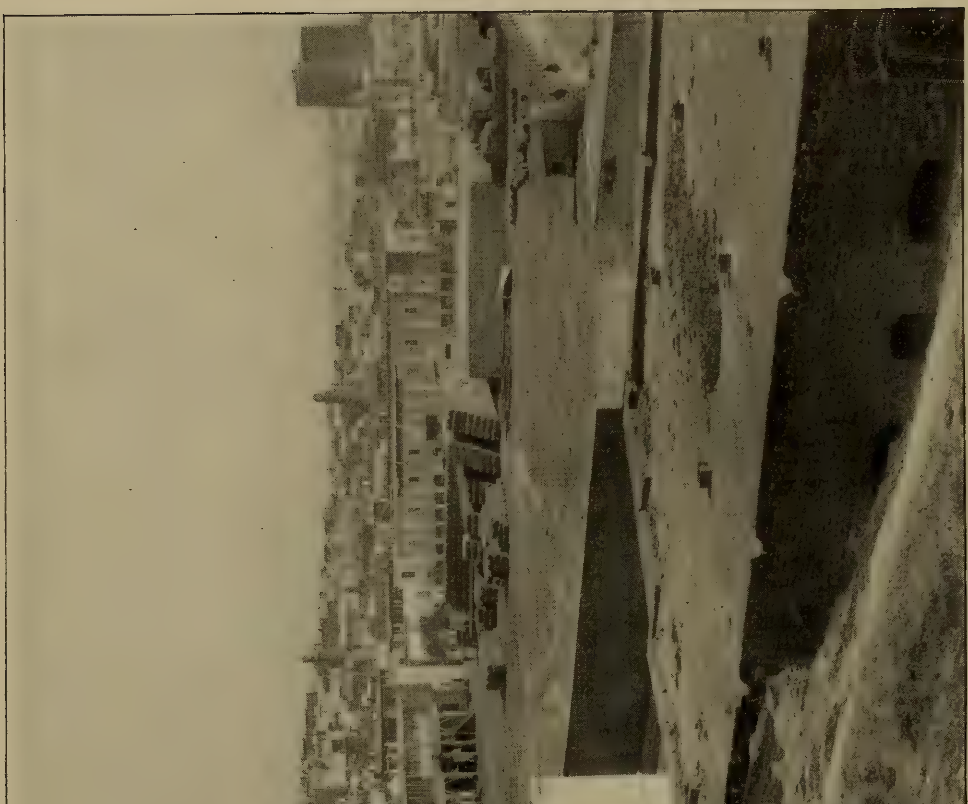
A RUSSIAN PETROLEUM PIPE LINE

CARRYING OIL FROM BAKU TO BATOUM

By Ernest H. Foster

TWO MEANS OF TRANSPORTING OIL,—TANK CARS AND CAMELS

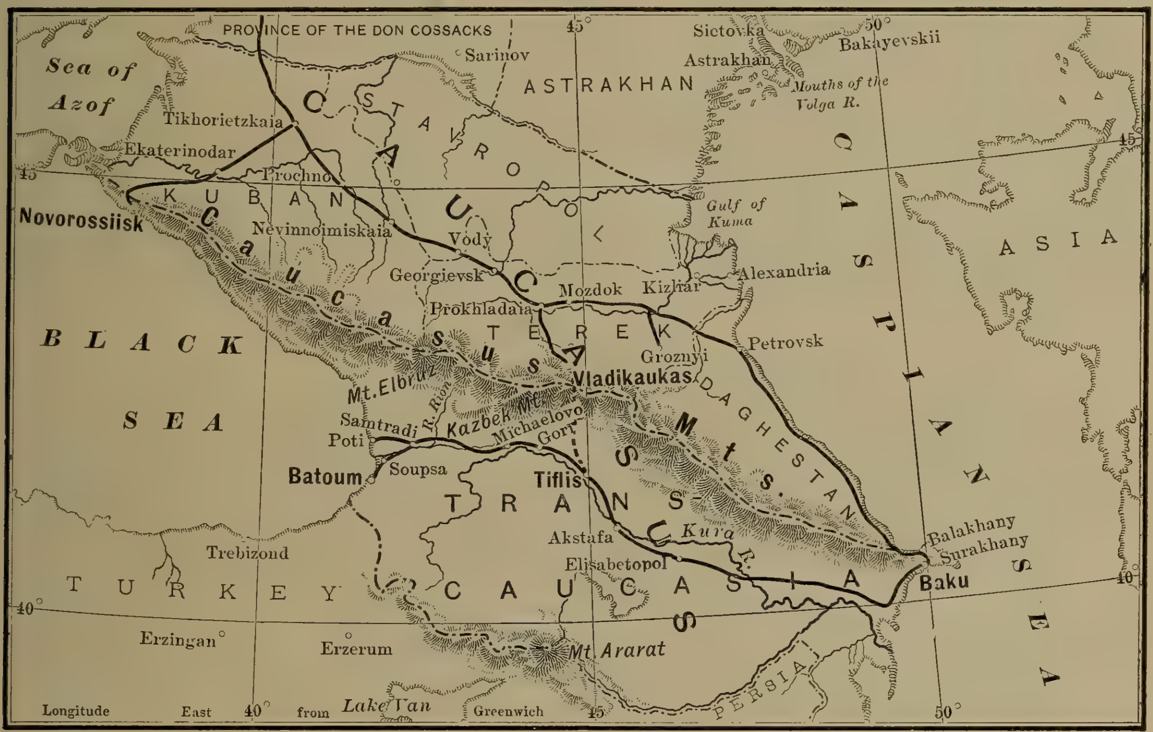
NO railway line could present a greater variety of scenery or a more interesting collection of natives, seeming to differ radically in feature and dress at almost every stopping place, than does the Russian Imperial Transcaucasian Railway, which connects the Black and Caspian Seas, and almost parallels the southern slope of that majestic range of lofty mountains which marks the dividing line between Europe and Asia. This so effectually separates the north from the south that up to the present year all of the very considerable traffic not carried around by either the Black or Caspian Sea, by some of the half-dozen or so well-equipped steamship lines, must of necessity have been dragged by horses over 140 miles of the famous Georgian military road which connects Vladikavkas, on the north, with Tiflis, on the south,



THE OIL CITY OF BAKU

and climbs to a height of 7000 feet, being frequently made impassable by snow for days or weeks during the winter months, notwithstanding numerous sheds and snow tunnels. This year, however, after much difficulty with unmanageable rivers, a continuation of the Vladikavkas Railway has been pushed around the eastern end of the mountains, skirting the shore of the Caspian Sea, and establishing a through railway connection in corn fields and dense woods. At this point the foot of a north and south mountain chain is reached, and within the next thirty-four miles the road ascends 1970 feet, reaching an elevation, above the sea, of 2485 feet, the summit being half way through a tunnel about five miles long, which was completed about six years ago.

The mountain scenery through the pass is wild and romantic, almost be-



A MAP OF TRANSCAUCASIA, SHOWING THE LOCATION OF THE PIPE LINE. THIS FOLLOWS THE LINE OF THE RAILWAY

with the system south of the dividing range.

The Transcaucasian Railway leaves the eastern shore of the Black Sea at two points. The original line ran from the harbour of Poti, and certain classes of exports, chief among which is manganese ore, are still brought exclusively to this port for shipment. Some years later the railway was extended to the much superior harbour of Batoum, and it is from this port that the oil export trade is carried on.

Following the road back from the sea, the country continues flat for about eighty miles. It is exceedingly fertile, semi-tropical in climate, and abounds yond description. The rich beauties of nature are materially assisted by numerous ruins of mediæval castles and strongholds, most effectively placed upon high and commanding points. It is said that the inhabitants were peaceably inclined, but were obliged to keep constant lookouts for the warlike Tartars, who frequently made hostile invasions.

The original line followed the valleys of the Rion and Keirila Rivers, and took advantage of the river bed in many instances to cheapen the cost of construction. Severe washouts and land-slips, however, induced the government engineers to raise the level of the road-

AN ANCIENT FIRE-WORSHIPPERS' TEMPLE NEAR BALAKHANI

bed considerably, so that the present line is quite free from similar dangers. Several interesting engineering problems are noticed in passing over the line. In one place a tunnel was constructed through which the river was diverted, while the bed of the river was used for the railway.

The district around Poti and Batoum was part of Turkey until after the last war between Turkey and Russia. The natives here are, therefore, mostly Turks and Greeks, and wear costumes adapted to a warm climate, whereas, on the mountains, although but a few miles away, the natives not only speak a different language, but are of an entirely different appearance, and wear clothing suitable for a cold climate. After crossing the mountains the road descends more gradually, and reaches the sea level just beyond Eblahk, 240 miles from the tunnel. From this point the road runs directly to Baku over 180 miles of desert land. Except for an occasional Tartar settlement or government railway station, not a house is to be seen, and the only signs of life are a stray horseman or an occasional camel-train. The level of the track is now above and now below the sea, the lowest point being 70 feet below the level of the Black Sea. On the north the mountains recede, and are replaced by a low outline of hills absolutely devoid of verdure, whereas on the south the river, which has accompanied the road from the summit of the mountain, gradually diverges and empties into the Caspian Sea about 100 miles from Baku.

It is supposed that this river bed once took the same course as the present railway, since unmistakable signs of former villages and even farms are constantly being unearthed in this arid region. Doubtless the contour of the country has been changed by volcanic eruptions. Within the past ten or twelve years such outbreaks have occurred within a few miles of Baku, while even during the past few months severe earthquakes have visited the more western districts, somewhat higher up on the mountains.

On approaching Baku evidences of the oil fields become visible on all sides, and great cities of black derricks, set so close together that they appear like a dense forest, mark the well-defined area of the productive field. As the train circles around a well-sized hill the city of Baku bursts upon the vision with startling suddenness, and one is soon

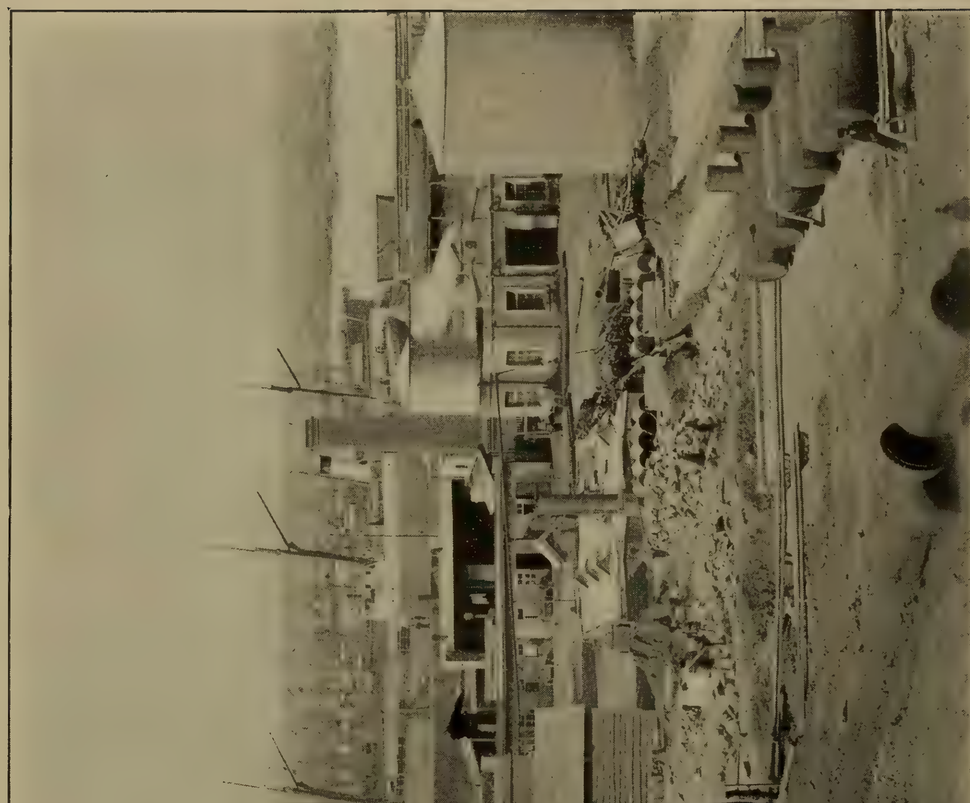
in what might well be called one of the most interesting cities of modern times. It lies on the sloping shore of the very salty Caspian Sea, and is credited by ancient legends to have once borne the name which in the Tartar language means City of Roses. Nothing, however, could be more inappropriate at the present time, when the ruling impression is the complete absence of verdure, due to a lack of fresh water supply. All the water used by this city of over 75,000 inhabitants is now either distilled from the sea water, brought in tank cars from the distant rivers, or borne in casks on the backs of horses or camels from very carefully preserved wells in the vicinity and fed by not too frequent rains. Various projects have been drawn, at the instigation of the local authorities, to bring water from the rivers lying to the north and west, and, while there are difficulties to be overcome in each case, there seems to be no real reason for not doing so, except the impossibility hitherto of bringing those interested to an agreement.

The city of Baku was taken from Persia by Peter the Great of Russia about two hundred years ago, and, although the process of Russianising has been going on steadily ever since then, the city still retains many of its Persian characteristics. The old wall of the inner city is well preserved, and many of the buildings, particularly the abandoned palace in the centre, are said to be excellent examples of Persian architecture. The old city wall at one time probably extended quite down to the water's edge, but the steady lowering of the level of the Caspian Sea, which has been going on year after year, has gradually left a considerable strip of land between the old wall and the water. A fine quay has been constructed, and the long row of docks and great quantity of shipping always to be found here are remarkable for an inland sea.

A NEAR VIEW OF SOME OF THE HOUSES OF BAKU

As a business centre Baku has acquired considerable wealth, and the new city, which has naturally extended in all directions, contains substantially built, indeed elegant, stone houses and large shops which would do credit to any city of Europe. The streets are rapidly being paved, and they will soon be better, in this respect, than those of any other town in Russia, with the exception of St. Petersburg.

Evidences of wealth are not only to be seen in the appearance of the city itself, but also among many of its inhabitants. It is not an uncommon sight to

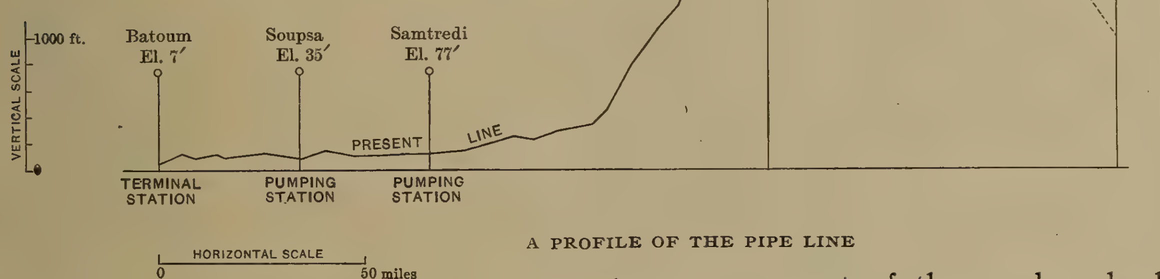


THE DOCKS AT BAKU

see a Tartar or Persian who is worth a fortune, but who cannot write his own name, and has no idea of the world outside of the city of Baku. It is said, however, that most of these people who have suddenly risen to great wealth by the fortunate holding of valuable oil land, have the ability to keep their fortune together, and it is not uncommon for them to deposit their money in English banks through local agencies.

The most productive oil fields are to be found in the vicinity of Baku. The field at Ali Baba is nearer to the city, but is not so large in extent nor so productive as Balakhani, which lies ten miles to the northeast. Both of these towns are one mass of derricks and engine houses, and everything about the place appears to be saturated with petroleum. Borings are constantly being made and oil is generally found at a depth of from 500 to 1000 feet. A few years ago it was common to open up large spouting wells, but these have fallen off considerably during later years; occasionally, however, a fountain is produced, and it sometimes happens that an explosion of gas in a well that is being pumped not only blows all the apparatus out of the tube, but produces a natural flow of oil to the surface.

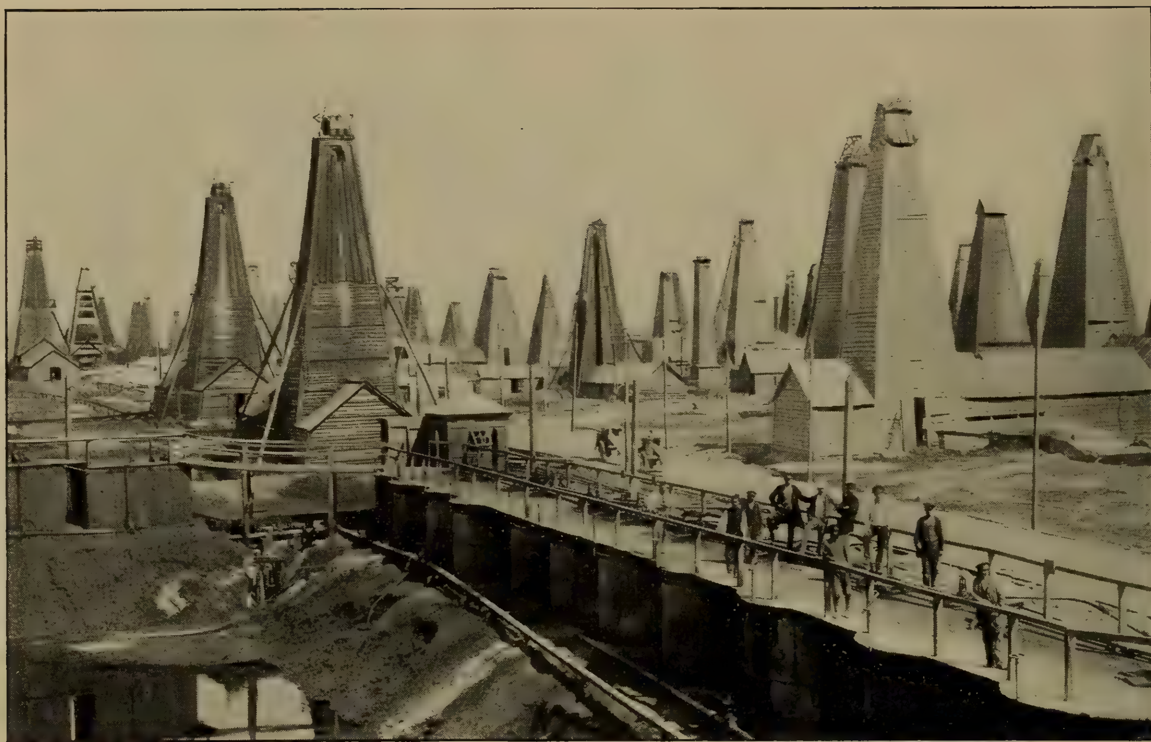
Well tubes are usually started from 16 to 20 inches in diameter, being much larger in this respect than in American practice. These diameters are reduced as the depth increases, the last section of tubing being hardly more than from 8 to 10 inches in diameter. The most successful system of working the wells in this district is by the use of the bailer, which consists of a 30 or 40-foot length of 8 or 10-inch pipe with a valve at the bottom. This bailer is let down into the well, where it is filled with oil through the bottom valve, and is then raised by a hoisting engine until just above the top of the well. The operator then places a wooden cap over the top of the well, lowers the bailer gently so that the valve rests on the cap and opens, allowing the oil to flow out in all directions, being conducted, by means of trenches, to a receiving pool. The operator then draws the bailer up a few inches, removes the cap from the well, and lets the bailer drop down again to near the bottom of the well. Care is taken not to bail from the bottom, on account of the sand and salt water which are apt to accumulate there.



A PROFILE OF THE PIPE LINE

The time consumed in lowering, raising, and discharging the bailer of a 1000-foot well is only about one minute for a round trip, and the whole operation is conducted by one man, who starts and stops the hoisting engine, controls the brake on the drum, and empties the bailer. Many experiments have been tried with pumps on the American system, and tests are now being made on a larger scale by using air lifts, but the great quantity of sand in the oil and the danger of losing the whole apparatus by an explosion of gas makes the bailer system more favourable from a practical and economical point of view.

The wells are placed so close together in the oil fields that "shooting" them with dynamite is prohibited on account of danger of injury to neighbouring property. Nearly all the good oil prop-



OIL WELLS AT BALAKHANI

erty is in the hands of operators, although some of it still belongs to the government, and every now and then parcels of land are auctioned off to the highest bidder at public sale.

Not very far from Balakhani, near Surakhan, are the well-preserved remains of the old fire-worshippers' temple, which is said to have been erected by Zoroaster. Whether this is true or not, evidences of great age are certainly abundant, and it is known that even to within a few years ago pilgrimages of fire-worshippers from India were made to this spot. In and about the temple natural gas issues from the ground in abundance. It is necessary to dig only a few feet below the surface when the gas accumulates, and it can be readily lighted. It is not uncommon to see native Tartar lime-kilns or stoves made by merely digging into the ground to a small depth, arranging a loose pile of stones over the excavation, and lighting the gas as it escapes from the crevices. This natural gas is conducted through the hollow walls of the temple, sometimes aided by the use of small iron pipes, and burns at different points around the top, and also in certain shrines which have been constructed for this purpose and which are completely devoid of decoration, with the exception of the bare pillars and domes. The gas burns at a low pressure, and can be readily blown out and relighted. The flame is rather bluish and does not give much light; at night it presents a most weird appearance. Ancient stone beds and stalls, with mangers hewn out of the stone, for the pilgrims and their beasts, still remain in the hollow walls, and various small chapels and dungeon-like rooms doubtless appear very much as they did in times far back.

Most of the crude oil from the field is pumped through pipe lines to the refineries, which are generally situated on the seashore, chiefly in the suburb called Black Town. Some of the oil is transported in tank cars, but the old system of carrying it on mule or horseback in buckets or tubs is not entirely extinct. The crude oil refines to 38 or 40 per cent. kerosene, a large part of the residue being a thick tarry substance called "mazoot," which is used almost exclusively for fuel under boilers. The bulk of the refined oil and "mazoot" is loaded on steamers at the refineries, and

is shipped in them to the mouth of the River Volga, where it is reloaded on river boats and towed up the Volga to be transported through the canals and railways to the different parts of the Russian Empire.

A large amount of oil will doubtless be carried on the new Vladikavkas Railway extension by way of Petrovsk to the port of Novorossisk, but the principal export trade will continue to be by way of the Transcaucasian Railway to Batoum, where there are large casing factories in which the kerosene is put up in small rectangular tin cans before being loaded on steamers.

The rapid growth of industries in this section has so increased the traffic on the railway that the line became congested at the western end where, on account of the grades, the hauling is most difficult, and the conditions are aggravated by the influx of several branch lines. To seek relief in building a second track would have been very expensive, owing to the difficult nature of the country. About 80 per cent. of the traffic consists in carrying oil to Batoum, and the majority of this is refined petroleum; hence, the simplest remedy was to build a pipe line for refined oil, beginning at the western end and gradually extending easterly. The tank cars will still be used for carrying the heavier grades of oil through to Batoum.

A 4-inch pipe line, now abandoned, had been constructed across the mountains some years ago by one of the largest petroleum firms of Baku, and several offers to build the new line were made, but the government was unwilling that this project should pass into private ownership. The line was, therefore, built by the government, and is operated as a branch of the Transcaucasian Railway. The oil is received from the refineries in Baku at a certain standard grade, and is transported in the government tank cars to the first station of the pipe line, at a point near Michaelovo, about 418 miles from Baku, where it is run into large receiving tanks and pumped from there to Batoum and re-delivered to the dealers. The pipe line has a capacity of 48,000 gallons of oil per hour, and it is believed that this will be sufficient to very materially relieve the railway for a long time to come.

A FLOWING WELL ON FIRE

In preparing for the construction of the pipe line the Russian Government sent competent engineers to Europe and

THE OIL REFINERY AT BLACKTOWN

America to examine into the construction of pipe and pumping machinery with a view to obtaining the best practice. The line was open for service during the past summer, and, although it has cost about $2,600,000 (£520,000) to build it, everything has been done in a first-class and permanent manner, and great care has been taken with the details. The cost has been divided, approximately, as follows:—

Pipe line and reservoirs in place	$2,300,000	(£460,000)
Pumping machinery and boilers	200,000	(40,000)
Pumping stations and dwellings, and brick stack	55,000	(11,000)
Water supply for pumping stations	35,000	(7,000)

The principal item was for the purchase of pipe, and in this the government protected home manufacturers. It is generally known that a bid of less than 75 cents per foot was received from well-known American manufacturers, whereas the government ordered the pipe from a Russian works at a price of $2 per foot. It is true that the Russian works were new and in need of business to give them a start, but it is an interesting fact to note that the first thing they did was to send to America and buy a complete American pipe mill and equip the works with a corps of American managers and engineers.

Eight-inch steel pipe was used throughout the line, and the tests for strength and tightness were very severe. For instance, at the factory, after a minute examination, under a magnifying glass, of the pipe and threads, a length of pipe and a coupling were screwed together and subjected to a water pressure of 150 atmospheres and struck sharply several times with a one-pound hammer while under pressure. The pressure was kept on for several minutes. After being delivered to the railway company, another test, under a somewhat lighter pressure, was made. The pipe was then screwed together in place on the surface of the ground, and, as each length was added, the whole section from the starting-point was tested under a water pressure of 70 atmospheres. The pressure was kept on for several minutes and a careful inspection made for the slightest leak in any of the joints. In this way the first lengths of pipe to be laid in any section were subjected to the test pressure a great many times, but doubts were thrown upon the wisdom of this method, as some of the lengths burst under 70 atmospheres after having stood the same pressure over twenty times, and even passing the much higher shop test.

THE PIPE LINE ALONG THE LINE OF THE RAILWAY

The pipe was made up in several sections, the ends being left plugged until the line was practically complete, when they were joined by an ingenious slip-joint coupling, made of cast steel and especially designed for the purpose. Considerable difficulty was, at first, experienced in getting the threads tight. The Russian engineers found some fault

ONE OF THE PUMPING STATIONS. THE CAR AT THE RIGHT WAS USED AS A DWELLING BY THE WRITER

with the American system in that the threads cut too deeply into the pipe at the vanishing point, which, in their opinion, weakened the cross-section unnecessarily. They, therefore, designed a modification of the American thread which caused it to vanish on the pipe in a carefully cut cone; they also provided a cone edge on the sleeve coupling, which was to bear on the cone of the pipe when the thread was made up. This system had the effect of drawing the pipe off the thread when it was screwed up hard and caused leakage. The difficulty was finally overcome by designing a tool, similar to a boiler-tube expander, which was inserted in the pipe after it was screwed up hard, and the threaded part was rolled out to set firmly in the coupling.

After the pipe was put together on the surface of the ground, it was tarred on the outside and buried to a depth of from 12 to 18 inches to protect it from external damage as well as the sun's rays. The line was laid parallel to, and within a few feet of, the railway; consequently the grading of the railway bed was utilised for the pipe line. The curves were followed by bent pipe, the lengths being heated in a wood fire in the field and formed to the necessary shape. Stop valves were provided at frequent intervals. In the mountainous districts the distance between them was from one-half to three-quarters of a mile, whereas in the level stretches they were placed from five to six miles apart.

The total length of pipe contemplated was about 230 miles, to start from Ag Taglia, a small station on the railroad just before reaching Tiflis, whereas the portion actually constructed and opened last summer runs about 141 miles inland from Batoum. In this line there are three main pumping stations, the distance from the first to the second being seventy-seven miles, while the distances from the second to the third, and from there to Batoum are about thirty-two miles each.

The stations were designed to have about the same pumping pressure at each, but a glance at the profile will readily explain why the distance between stations is unequal. From the first station the pipe rises 350 feet to the tunnel and then descends 2410 feet to the second station; from there on the line is practically level until Batoum is reached.

The first pumping station has a larger equipment than the others, being the seat of management and a more important point on the railway. At this station there are three large receiving reservoirs, with a capacity of 600,000 gallons, and two smaller reservoirs, which contain 250,000 gallons. The oil is received from the tank cars, which are run on sidings and drained into covered steel troughs, running parallel to the tracks. The oil flows by gravity into the smaller receiving reservoirs, whence it is pumped, by low-service pumps, into the large receiving tanks. These latter are on a level with the main pumping engines, which therefore take the oil, under a slight head, and deliver it directly into the pipe line.

The low-service pumps are of Russian manufacture, but the main pumping engines are of the Worthington compound, high-duty type, with 21-inch high-pressure and 42-inch low-pressure steam cylinders, 8½-inch plunger, and 24-inch stroke. They are fitted with Worthington compensating cylinders and differential accumulators, being

A CAUCASIAN "HORSELESS" VEHICLE

similar to the type of engine used in many of the American pipe-line pumping stations. The pressure on the pumps when delivering the maximum guaranteed quantity of petroleum is 645 pounds to the square inch. The pumps run at a piston speed of 140 feet per minute. All the pumping engines are in duplicate. The boilers are of the Lancashire type, and are fired with the already mentioned by-product of petro-

THE MARKET-PLACE AT BAKU

leum known as mazoot. There are six boilers at the first pumping station, and four at each of the other two stations. The stacks in each case are of brick, 110 feet high.

The pump and boiler houses are built of cut stone, and have mosaic floors and iron roofs. There is no woodwork about the buildings, and they are intended to be fireproof; consequently, no fire-protection system has been installed, as is common at the American pipe-line pumping stations. Water happened to be scarce at the points where it was necessary to locate the stations; hence more or less expensive waterworks were built to bring the water from the rivers. At the first station large settling basins were necessary, owing to the turbid state, during certain seasons of the year, of the river water from which the supply is drawn. The condensing water is discharged from the air pumps, which are driven by the main engines, through a Koerting cooling system, which consists of a series of jets or fountains, from which water is sprayed over a basin in which

it is collected and filters through sand into an end channel from which the injection water is drawn. The boilers are fed by injectors which draw their water from this basin, but each boiler house is supplied with a duplex steam pump as a reserve.

At each pumping station there are three large oil receiving tanks, with a capacity of 600,000 gallons each, into which the pumps from the previous station deliver, and from which the oil is drawn to be forced to the next station. In addition to this there is a smaller tank at each station to contain mazoot, which must flow to the boiler under a slight head or be forced into the burners by a steam pump. The mazoot is warmed before burning by passing over the tops of the boiler setting.

Communication is established between each pumping station by means of telephone, and, as each station is located near a railway station, telegraphic communication is also available. The whole character of the construction throughout this pipe line, including the engine and boiler houses, residences for employees, and the machinery, has the appearance of great solidity and permanence. The carrying capacity of the line is supposed to be 48,000 gallons per hour, with one engine in operation. It is probable that the present requirements will be met by pumping twelve or fourteen hours a day.

There is a fleet of over 300 steamers on the Caspian Sea, ranging as high as 1600 tons capacity, which burn the by-products of petroleum as fuel. This is true also of a few steamers on the Black Sea, as well as of all the locomotives of the Transcaucasian and the Vladikavkas railways, and on the switching engines of the northern roads in Russia, which use wood and coal on their regular trains.

It is quite probable that other large oil fields will be developed in different parts of the Caucasus before many years. Petroleum is found cropping out at the surface at a great many widely separated points in the neck of land between the Black and Caspian Seas, but thus far no wells of any great staying power have been discovered, in spite of a great many borings. Quite a promising field developed a few years ago at Grosney, on the north side of the mountains; but the oil from this field is of a poorer quality, and the output does not give much indication of materially increasing or even becoming permanent.

By keeping the control of the transportation of this valuable product in its hands, the Russian Government is able to regulate the price and exert a most restraining influence on the petroleum industry, and thus very little opportunity is left for the formation of trusts or monopolies, for which the Russian Government has such a deep-rooted abhorrence.

OIL WELL DERRICKS AT BALAKHANI

SMOKE ABATEMENT

THE RATIONAL SOLUTION OF THE PROBLEM

By William H. Bryan, M. Am. Soc. M. E.

THE emission of smoke, often densely black, has accompanied the use of soft, or bituminous coal, from the earliest times. It was, from the first, acknowledged to be a public nuisance, and has long been the object of repressive legislation. Its harmful effect on vegetation was noted centuries ago, and it was believed even to be poisonous to the human system. To such proportions had this nuisance grown in the reign of King Edward I., that the people of London petitioned that the use of "sea" coal be prohibited. A law to this effect was accordingly enacted, with the extreme penalty of death. Such a measure was, however, too radical, and it became necessary to modify the law; but the agitation of the subject has continued to this day.

It was natural that inventors should early turn their attention to the development of means for burning fuels without the emission of objectionable smoke. For years, indeed almost for centuries, this field has been prolific. With the increasing consumption of smoky fuels, and the growth of the use of steam, the activity of inventive genius has been increased. It has found the field ripe for harvest in the large cities of modern times, where extensive industrial plants are crowded together. Next to the perpetual motion crank, comes the man who claims to have invented a smoke consumer. His name is legion. Usually he has had no practical experience, and his ideas of the principles of combustion are hazy. More often than not his device is merely an idea which has not been reduced to practice. Sometimes a few experiments have been made on a small scale. Occasionally the apparatus has been developed far enough to be tried under a limited range of conditions. Few inventors, however, have any idea of the exacting demands which a successful smoke-preventing device must meet, and fewer still have put their devices to exhaustive test under the severe conditions of actual service. But they are always enthusiastic, no matter how absurd the principle on which they are working, or their method of applying it.

Hardly less harmful are those promoters, with some smattering knowledge of combustion, who offer their devices as the panacea for every ill of the smoky kind. Sometimes they guarantee results, taking chances that no expert test will be made in advance of acceptance. Many of them refuse to submit their apparatus to the exhaustive investigations of experts, knowing that its weaknesses and limitations would be developed.

As a result of this misdirected energy many devices have been installed, to be operated under conditions of service for which they are totally unfitted. Some meritorious ones have been imperfectly erected or adjusted, or were ignorantly handled. Others have proved costly

to maintain, or have failed to respond to fluctuating conditions. It is not surprising, therefore, that a large percentage of these so-called smoke preventers have proved to be failures, and that nearly all of them have been thrown out, at great loss to both purchaser and promoter. So discouraging was the outlook a few years ago that most manufacturers, as well as many progressive engineers, despaired of a solution, believing that there remained some particularly refractory conditions which no one of the devices on the market could fully meet.

Nevertheless, substantial progress in smoke prevention has been made. The conditions governing the making of smoke have been exhaustively studied, and many experiments towards its prevention have been made along scientific lines by competent experts. To prove that the problem has now been solved, it is only necessary to point to the hundreds of smokeless chimneys in many large cities, which serve furnaces burning inferior grades of soft coal, many of them operated continuously under most exacting conditions. The beneficent result is apparent wherever the problem has been attacked energetically and in good faith. The exhaustive study of this subject recently made by the Franklin Institute, of Philadelphia, at the request of the board of health of that city, has been productive of much good. Effective agitation has been carried on in many places for several years, and the matter has had consideration also with special reference to locomotives, and with good results.

It may be safely said, therefore, that any city may control its smoke. The means are ready at hand. Furthermore, such means are to be had in some variety, and their use imposes no undue hardship on manufacturers, either in first cost, restriction of output, or material increase of cost. The minute particles of almost pure carbon which accompany and give colour to the discharge gases from many furnaces, forming what we call smoke, are of little consequence in themselves. Experiment has shown that they form an inconsiderable percentage of the coal burned,—probably rarely over 15 parts by weight in 10,000. These particles have great colouring power, however, and this gives rise to the idea that they represent large fuel waste. Great economies were accordingly expected to follow the introduction of smokeless furnaces, but these anticipations have seldom been realised.

It is, nevertheless, true that the conditions which most favour the making of smoke are conditions prejudicial to good fuel economy. Many of the most meritorious devices for smoke abatement accomplish the result by more intelligent and scientific furnace conditions, intended primarily to improve the fuel efficiency. It is equally true that a clear chimney does not necessarily imply perfect combustion. Colourless discharge gases often contain an excess of carbonic oxide and of free oxygen, which are the results of imperfect combustion.

In the efforts to get rid of the smoke it has been learned how to burn coal more properly. The average furnace of the present day has an efficiency at least 15 per cent. greater than the average furnace of twenty years ago. The methods of determining the efficiency of furnaces are also more complete, and instruments and apparatus more elaborate and exact. A preliminary study of the fuel to be burned in any given case permits the design of the best form of furnace, and the determination of the best means of handling it.

It would seem unnecessary at this day to enter upon any argument to prove the harmful effects of smoke. Almost without exception, the courts have held that it is a common or public nuisance, and that it is only necessary to prove its existence to incur the stipulated penalty. Many kinds of manufacturing cannot be carried on at all in a smoke-laden atmosphere. We know that it is a menace to health, and is particularly harmful in cases of eye, lung, and throat disease. We recognise its grimy touch on the façades of many costly buildings. Soot spots on face, hands, and raiment follow every trip in the open air. No city can be a happy one which is con-

tinually under the pall of a dense smoke cloud.

Generally speaking, smoke is due primarily to incomplete combustion. Fuels are made up of volatile matter, fixed carbon, and ash. In bituminous fuels, which are always smoky, the volatile constituents are high. When such fuels are thrown into a furnace the volatile matter first passes off in a gaseous state, principally as hydro-carbons. Part of these are of the olefiant series, which are dissociated at a red heat, setting part of the carbon free. If sufficient oxygen be present, and if the temperature be high, this separated carbon will burn, but in the absence of either condition or of both conditions, it passes off unconsumed, forming the visible smoke.

Incomplete combustion may result from many causes. The furnace may be of improper design in some one or more of its many details. It may be overworked, or it may be carelessly handled, or the fuel may be of inferior quality. All these things may be easily remedied. There is nowadays no excuse for bad furnace design, overloading, or unskillful firing. A furnace properly designed for its work, and skillfully handled, is capable of burning the most inferior fuel smokelessly and efficiently.

Smoke-making furnaces may be classed into domestic and industrial. As a rule, domestic fires are not great offenders. While they are large in number, the individual output of smoke is small. They are scattered over wide areas of comparatively thinly-settled territory, and their service is more or less intermittent. Furthermore, a large portion of them burn smokeless fuels, either hard coal or coke in the heating furnaces, and coke, gas, or gasoline in the kitchens. Among the industrial furnaces, those in steel mills, brick yards, and gas works have been large smoke-makers, but even these are yielding to improved methods and can no longer be considered serious offenders.

The largest smoke-makers, and the most difficult to deal with, have always been the furnaces of steam boilers, and it is to these that this article is particularly addressed. Under certain conditions of wind and atmosphere the smoke from tall chimneys may be carried long distances, and its damaging and polluting effects may be felt many miles away. No war against the smoke nuisance can be waged successfully without a good working ordinance, clearly defining the character of the smoke emission which is unlawful, and providing suitable penalties. Many such ordinances have been passed; in fact, nearly all the larger cities of the United States have enacted legislation of this kind. Much of this was experimental, and, when carried into the courts, did not withstand the attacks of opposing counsel. Many ordinances were declared invalid, but some have been upheld by the higher courts.

In addition to providing a good ordinance, a municipality can help the movement in other ways. It can provide an expert commission, to aid smoke makers in finding proper remedies, and to investigate and test improved devices. And, most important of all, it can take the lead and set a good example by stopping the smoke from its own furnaces, in waterworks, schools, public buildings and institutions.

With such wide-spreading knowledge of the harmful effects of smoke, it seems surprising that there should be any opposition to its abatement. A smoke movement in any community has almost universal encouragement and support at its inception, and it is only after repressive measures have been adopted that dissatisfaction begins to develop. It was to be expected that all would favour doing away with smoke when it cost the individual nothing. But when a particular offender is called upon as a good citizen to do his share of the general duty, he is not always ready. It is then that we hear that the prevention of smoke is a hardship to the manufacturer, that he cannot conduct his business successfully without making smoke, and that smoky chimneys are an evidence of business and prosperity, and that a busy community, even if smoky,

is better to live in than an inactive one, even though it may have a clear sky. The answer is simply that smokeless chimneys are not inconsistent with the greatest industrial activity and the economical use of low-grade fuels.

A large majority of the owners of smoke-making plants will promptly recognise their duty as good citizens by taking effective steps to abate the nuisance, but there are always a few who are slow to act until they find themselves in the category of law-breakers. In addition to those who oppose the enforcement of the ordinances in more or less good faith, there is usually a very small minority who are so lacking in public spirit that they will continue to pollute the atmosphere, even after abundant evidence has been presented showing that it is possible to stop the smoke without injury. Patience at length ceases to be a virtue, and the full force of the law must be brought to bear upon them.

Nevertheless, the greater part of the good effected has resulted from the use of conciliatory measures. Moral suasion is much more effective than force, and the law should be called upon only as a last resort. The best results have been secured where public sentiment has crystallised in an association composed of the most progressive people of the city. Such an association often has its own engineers, inspectors, and attorneys. The inspectors canvass the city, and talk with owners, and with the men operating the plants, endeavouring to enlist their co-operation. Often the association's engineers visit the plant and advise methods of firing, as well as details of reconstruction, if that seems necessary.

The greatest care must be taken to avoid the advocating of particular devices, to the exclusion of others, but the names of several suitable for the work should be given to the owner to choose from. He must be particularly impressed with the fact that his duty does not end with the mere purchase and erection of a good device, but that it is equally incumbent upon him to see that his men operate and maintain it properly. It must not be expected to run itself. Practically all failures of smoke-abating devices are due either to the fact that the device selected was not suited to the work, or that it was not properly handled or cared for after being put in. The main result, the abatement of the smoke, is the object to be kept always in sight, and the owner should be allowed the widest possible latitude as to methods. There is ample choice, suited to any pocketbook. Efforts of this kind will, in a majority of cases, accomplish the desired result.

It costs something to abate smoke, but this is true of every movement for the public good. It is true of good streets, and of better cleaned and sprinkled streets, of pure water, and of countless other benefits we enjoy. But these costs, at most, are not greater than the community has a right to call upon the individual to bear for the general good. They need not, however, be great. The best smoke-abating devices effect a saving in fuel which will pay a large return on the investment; often it repays the entire outlay in a year or two. Many improved furnaces have been installed wholly on account of their fuel efficiency, and are in use where the abatement of smoke is of minor importance. Smokeless fires under boilers mean clean heating surfaces, and absence of soot materially improves both the efficiency and capacity.

A prime essential is, of course, that the head of the establishment give the matter sufficient attention, to see not only that his men are provided with suitable equipment for abating smoke, but that they give it the necessary attention to secure results. This may sometimes mean the reconstruction of the furnaces, or it may mean some increased expense in the fireroom where the plant may be overworked, or where a more intelligent class of men may be required. It may even mean, in some rare cases, the use of a somewhat higher grade of fuel.

Some of the conditions which experience has shown to be necessary for abating smoke are higher firebox temperatures, good draught, proper supply

of air, neither too much nor too little, and its thorough mixture with the fuel, regular cleaning, uniform and regular supply of fuel, and its even distribution over the grate surface. It is the object of all the improved and patented devices to bring about these conditions, but, after all, no feature is so potent for good as skillful handling. The fact should never be lost sight of that the proper method of consuming, abating, or preventing smoke is to not make it at all, a result readily achieved by suitable furnace design and operation.

The smoke movement has brought about, among other things, a better understanding and appreciation of the boiler room. It has, unfortunately, been the custom too often for the chief engineer to devote practically all of his attention to the engine room, considering it beneath his dignity to spend much of his time in the dark and often dirty fireroom. But it pays to watch the boiler room; it pays to keep the apparatus in prime condition, and to fire skillfully; it pays to watch fuel and firemen, and to see that brains are put into the handling of the coal shovels; it pays to educate firemen in the most economical methods, and to encourage them by paying adequate salaries; it pays also to give the fireman all the light, air, and room possible, and to supply him with proper tools. In short, give the fireman a chance, for he cannot do himself or his employer justice with insufficient tools, in a dark, dirty, poorly-ventilated, and crowded fireroom, with a temperature at times almost unbearable.

In many localities the greater cost of smokeless fuels is so little as to warrant their more extensive use. Among these may be mentioned gas, oil, anthracite coal, coke, and semi-bituminous coals. Gas, oil, and naphtha engines are now quite common. In many cities electricity has proved potent in reducing smoke. Motors, operated by current from central stations, can now be rented at low figures. These, with gas and oil engines, and some compressed air motors, have frequently been substituted for small steam-engines and boilers, which latter are often serious offenders, and very difficult to improve. These later types of motor have advantages aside from the smoke question, such as lower cost, absence of heat, dust, ashes, and less labour and storage space required.

The successful smoke-abating device under a steam boiler must meet exacting conditions. It must be effective not only at rated load, but at both excessive under and overloads, the former being even more difficult to handle than the latter. It must be simple, and easily operated and maintained, reasonable in first cost, and, if it does not reduce the fuel consumption, it should at least not materially increase it. It must not occupy much space, but must handle inferior grades of fuel, even when overworked, and should require little extra attention.

What are the means of abatement in most general use? There is an endless variety, and not all of them have been equally successful. Some are quite limited in range,—hardly more than makeshifts. Some are almost automatic, while others demand constant attention. Some effect a fuel-saving, others cause an increase. Each individual case should be studied until the conditions of its service are fully understood, after which an intelligent application of the proper remedies may be made.

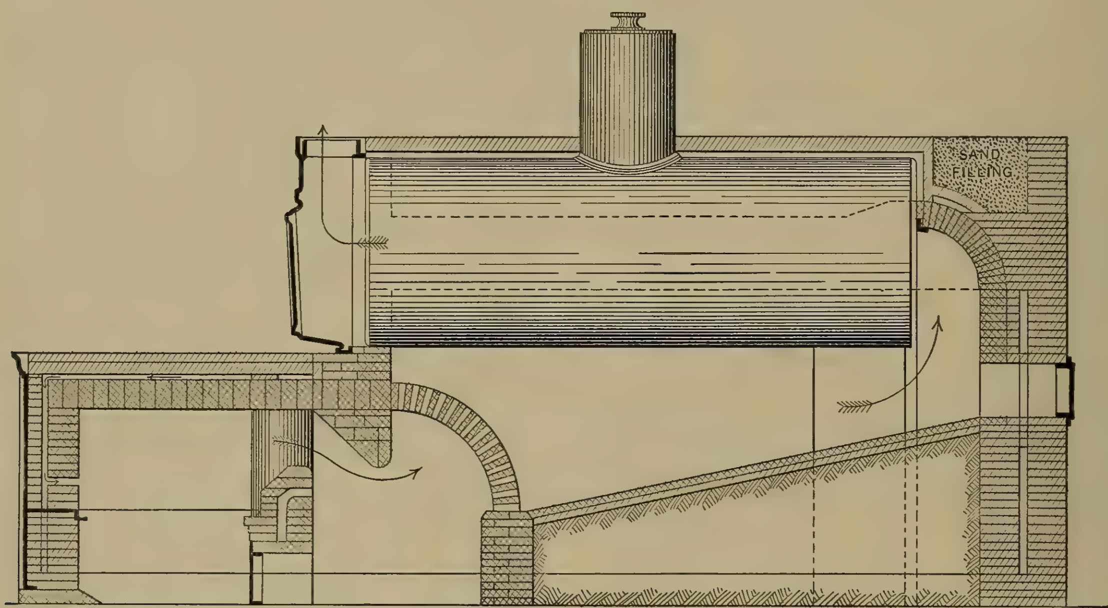
In practically every case the owner may make a selection from quite a variety of devices, any one of which will do his work satisfactorily. In extremely severe service the choice is more limited, but the writer has never found a case where more than one remedy was not available.

Nothing more is needed in some cases than good furnace design and skillful firing. Where the work done is well within the capacity of the plant, and the demand is reasonably uniform and the fuel good, it is often possible for a good fireman to keep the smoke within reasonable bounds without the use of any special apparatus. Firemen have too long been classed among unskilled labourers. The efficient performance of their duties really calls for high skill,

and their work rises to the dignity of a profession,—even of an art. It is manifestly impossible here to give detailed instructions as to the best methods of firing. Everything depends upon the fuel, the furnace, and the service required of it. The important points to be kept in mind are, frequent firing of small and uniform quantities of fuel, carrying a fire bed of uniform thickness, some admission of air above the grates after firing, and keeping the fires clean. The commonly employed "sprinkling" method, and the charging of adjoining doors at the same time, are less efficient than the "coking" system, firing alternate doors. In a case which came under the writer's observation the adoption of rational methods of firing effected a fuel economy of 15 per cent., besides largely reducing the smoke.

Where the work is above, say, two-thirds of the boiler's rating, and subject to some fluctuation, where the furnace design is not the best, where inferior fuels are burned, and where intelligent or skillful firemen are not available, resort must be had to special apparatus. This may be divided into four general classes.

I. Steam Jets.—These are the simplest and most inexpensive of all smoke-abating devices. Any engineer can rig one up, at small expense. They are sometimes placed under the grate, discharging into the ash-pit, but more often they are above the grate, immediately over the fire doors, discharging backwards and slightly downwards. The best results are secured when the steam jet is used as a means of drawing in air and discharging it at high velocity immediately above the fuel bed, where it meets the gases being given off by the disintegrating fuel.



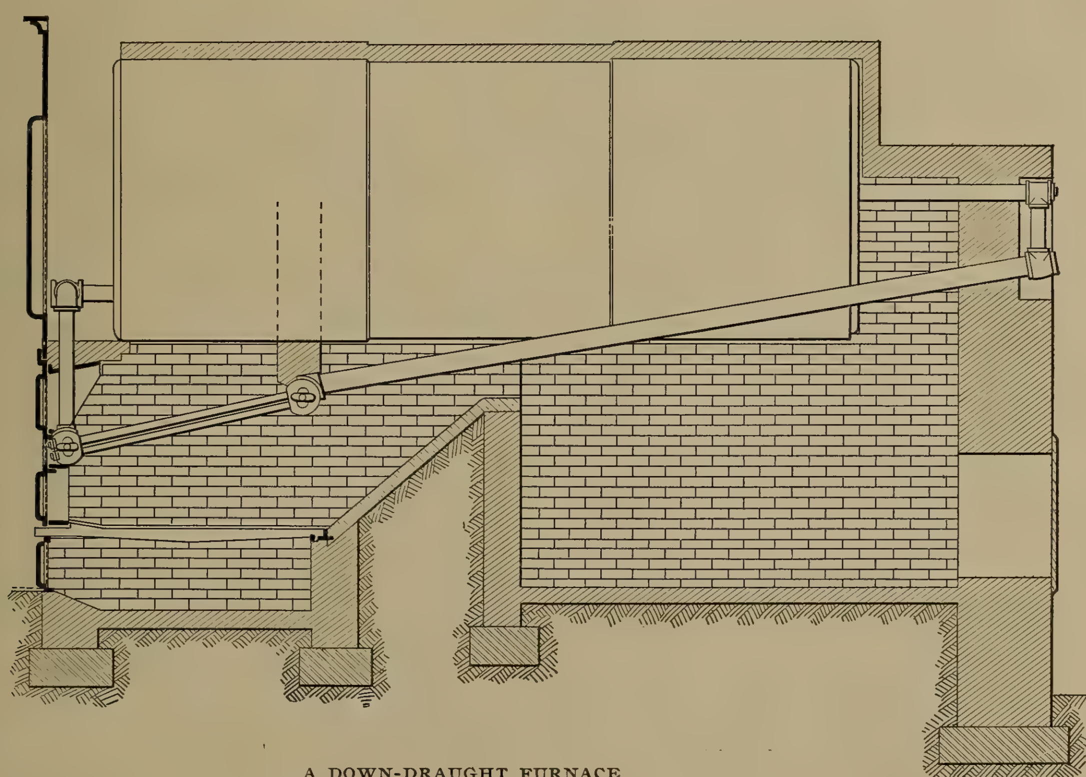
AN EXAMPLE OF FIRE-BRICK ARCH CONSTRUCTION

Such devices have come into extensive use. They are reasonably effective in smoke prevention, but are not economical in fuel. Usually the jets are allowed to blow continuously, but it is better to turn them on at the time of firing, and shut them off after two or three minutes when the fresh fuel has become ignited. In some devices this is done automatically, the act of opening the fire-door turning on the jet, and clock-work or dash-pot mechanism gradually closing it off. The objections to such devices are their first cost, complication, and the necessity for some attention and adjustment for fluctuating service.

II. Fire-brick Arches, or Coking Furnaces.—These come next in first cost, and, if properly designed and intelligently operated, are capable of

giving almost perfect results in smoke abatement. The fire-box is kept well away from the cooling effect of the heating surface, and can, therefore, be maintained at high temperature. Contracted checker work or throat areas insure a thorough mixture of air, which is often preheated. These designs are turned out in many forms, one being shown on the opposite page. The objections are that some forms require an increase of space, and the brick-work, if not properly constructed, may not be durable, and repairs may be large. In the best types, however, these objections have been very largely remedied. If properly constructed and operated, there will usually be a material saving of fuel over the common setting.

III. Down-draught Furnaces.—These have in many instances proved very successful, and they have come of the circulation system of the boiler. Ordinary grates would not withstand the high temperatures developed. The tubes are inclined upward to the rear, to insure rapid circulation. The space above the rear drum is closed off, so that the discharge gases must find their exit downward through the bed of fuel. Considerable partly-burned fuel falls through to the lower grates, where its combustion is completed under very favourable conditions. The two flames unite at the rear of the grates, forming a throat through which it is almost impossible for free carbon particles to pass unconsumed. Somewhat greater draught is required for this furnace than for the common setting. Most of the air required for combustion enters through the fire-doors above the upper grate, a small amount being admitted under the lower grate. This furnace is



A DOWN-DRAUGHT FURNACE

into extensive use, particularly where low-grade fuels are burned, and where excessive demands for overwork are frequently made. In one of the best-known forms, shown on this page, there are two grates, one above the other, the upper one consisting of a row of water tubes, single or staggered, forming part independent of the skill or ignorance of the fireman to a greater degree than many others. The objections are its first cost, and the fact that it is a part of the pressure system of the boiler. With bad water or inefficient or careless handling, there is some liability of frequent tube and drum repairs.

IV. Automatic Stokers. — With these may be classed chain grates and under-feed devices. They have come into extensive use, particularly in the larger and more modern plants, and are built in many forms, all operating on the same principle, that of automatic feeding of the coal to the grates in continuous and regular amounts. Most of them are designed for the use of the finer grades of coal, such as nut, pea, or slack. In most localities there is a surplus of this fuel, and its cost is low, but the increasing demand has raised the price and reduced the supply, so that it is now sometimes as high as lump coal. Many stoker plants are being provided with crushers to permit the use of the larger sizes when necessary. When accompanied by coal handling and storage plants the stoker greatly reduces the labour required in the fire-room, and this arrangement has been adopted in many large modern plants. The ability of the stoker to maintain practically uniform steam pressure, and the fact that the air supply is nearer the theoretical requirements, are features which have contributed largely to its success.

The objection to automatic stokers are:—1st, their cost; 2d, the complication of parts, and the necessity of some repairs; 3d, the power required to operate them. Under proper conditions there is a material saving in fuel and labour. That the objections named are not serious, is shown by their constantly increasing adoption. The fuel to be burned should have expert study before devices of this kind are selected, as they are not equally well adapted to all kinds of fuel. Some of them do not respond to widely fluctuating conditions of service, and extreme overloads, as well as other types of furnaces.

It is manifestly impossible to go into the details of all the methods which have been proposed, but the above covers, in a general way, all devices which may properly be called successful. The list might be extended to include double-combustion furnaces, smoke-washing apparatus, complete combustion devices, mechanical draught, etc. Some of these have come into limited use with encouraging results, both alone and in combination with others of the types named above. The above classifications are not clear and distinct, as the types named are quite often found in combination. The fire-brick arch, for instance, is nearly always found in combination with the stoker, and often with the steam jet.

Locomotive furnaces require special treatment, but it has been found that brick arches, or steam and air jets, give good results. The best work is done when the two are combined. The arrangement is, of course, not economical in fuel, although it has not proved itself particularly wasteful. Some experiments have been made with down-draught furnaces with promise of success. It is urgently recommended that larger grate and heating surfaces be provided on locomotives wherever possible. The above remarks apply equally well to steamboats.

Perhaps the earliest exhaustive study of the smoke-abatement problem was that conducted some years ago in the Smoke Abatement Exhibition at South Kensington, which was supplemented by a similar exhibition at Manchester, England. More recent are the investigations of the French Smoke Commission, begun in 1894. Their studies extended over a term of years, and the results have only recently been made public.

Exhaustive trials were made of a large number of devices, and prizes were awarded to the most successful. Stokers are in extensive use throughout Great Britain and the Continent of Europe, with excellent results, and some encouraging experiments have been made with powdered fuel, discharged into the furnace under pressure.

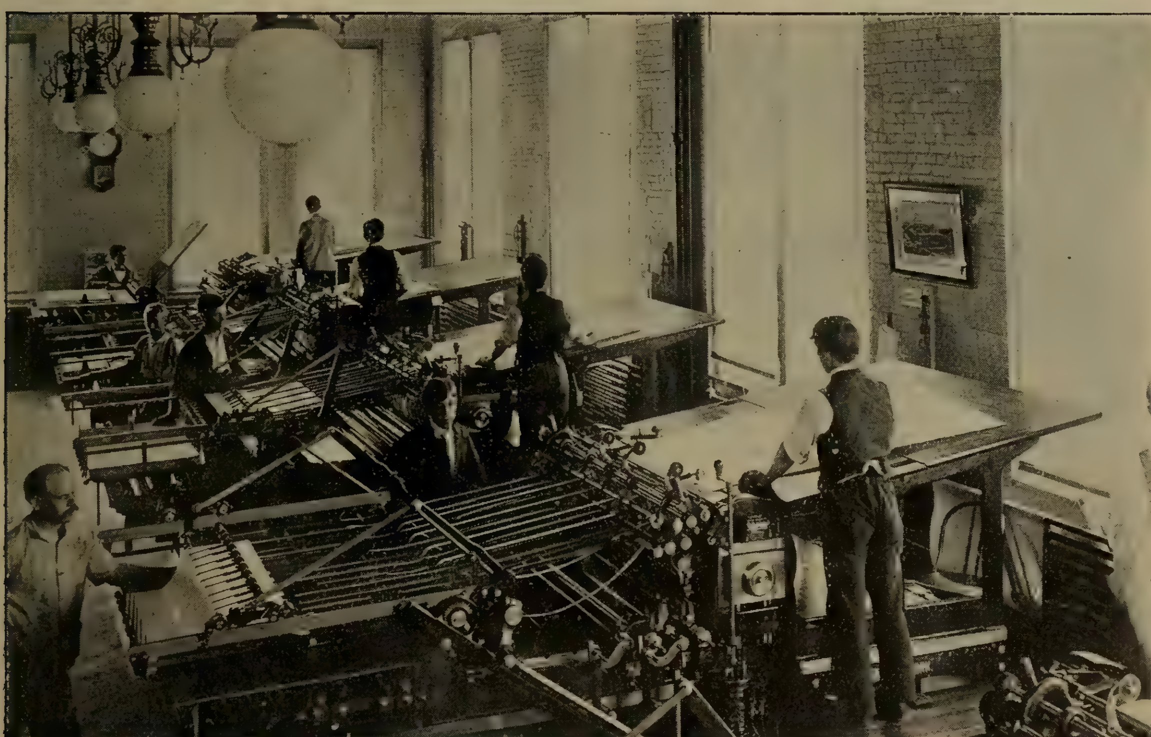
Workers in this field everywhere have abundant ground for congratulation as to the present state of the art. With the best design of furnaces, and more intelligent surroundings and manipulation, we may readily secure not only absence of smoke, but better boiler and furnace performance from every standpoint.

ELECTRICITY IN THE PRINTING OFFICE

By W. H. Tapley

AT the present time there is scarcely any branch of the art of printing which is not directly dependent upon, or greatly improved by, some application of electricity. The printing office in its broadest sense includes, together with the composing and press work, that of binding, electro and stereotyping, lithographing, and photo-lithographing, and from this standpoint as to breadth of scope, the introduction into it of electricity in its various forms has done much to make it an excellent representative of high-class industry.

The principal methods of application of electricity in printing are divided into four classes,—electro-plating, electric lighting, power, and heating. In newspaper offices these are increased by the extensive use of the telegraph and the telephone. Electro-plating, one of the earliest uses to which electricity was applied, reigned supreme and alone, excepting the telegraph, from about the year 1845 until the advent of the arc lamp in the late seventies, this being succeeded in a few years by the incandescent lamp, which, in turn, was followed by the adoption of the electric motor as a propelling agent for printing machinery. During the past three years electric heating has been assuming moderate importance in connection with the bindery branch of the art. Although one of the latest applications, the results obtained with this are so satisfactory that within the next few years electric heating will probably be one of the necessary adjuncts to a completely equipped printing office, quite as neces-

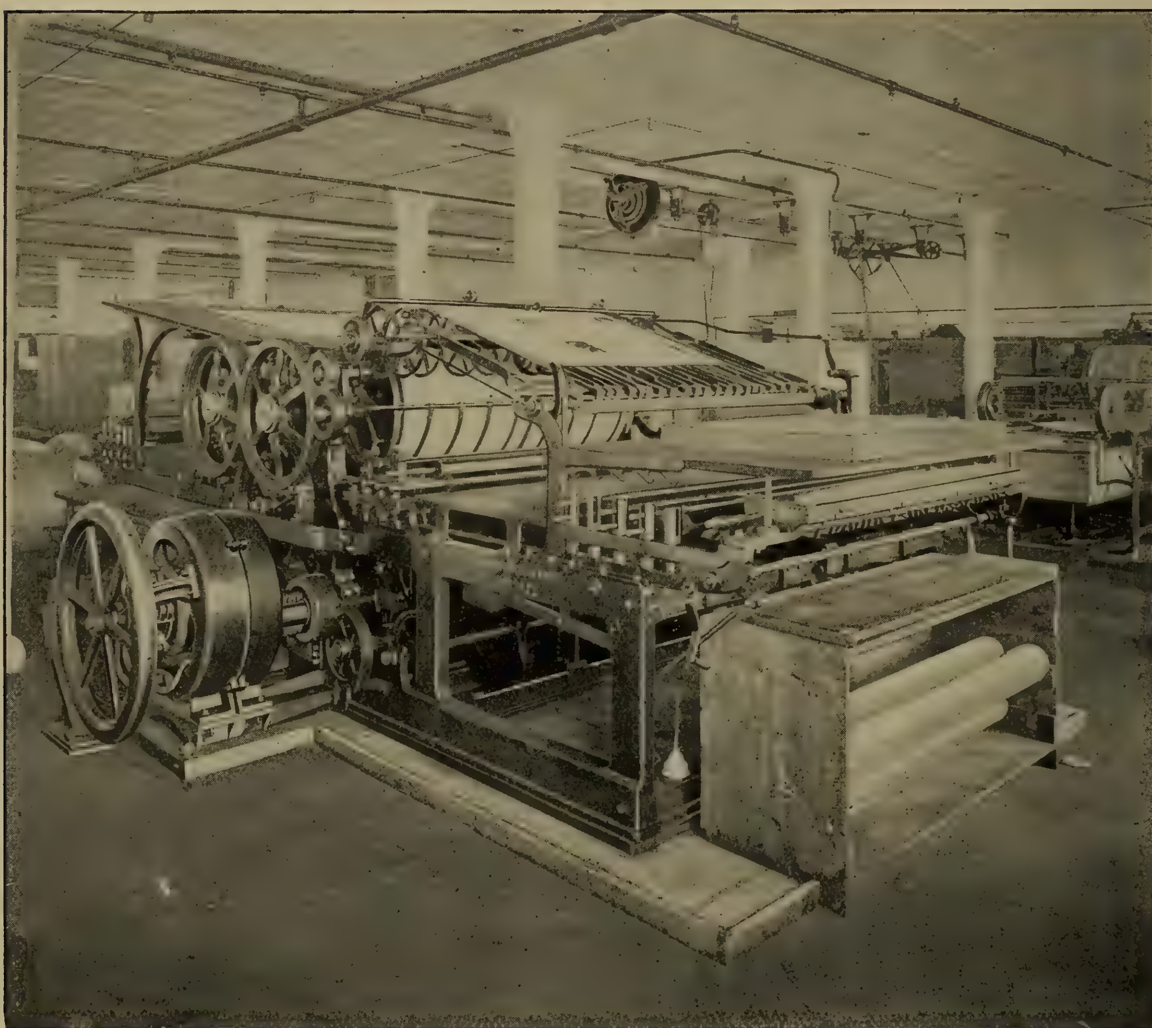


AN ILLUSTRATION OF THE SAVING IN LIGHT AND OF THE NEAT APPEARANCE OF A PRESS ROOM WHERE DIRECT DRIVING BY ELECTRIC MOTORS IS USED

sary, in fact, as electric lighting and electric motors.

Notwithstanding that electro-plating has been longest in use, it is the most neglected and least efficient application. The plating dynamos themselves have not been given the care in designing that all other classes of dynamo-electric machinery have received, and, as a rule, are built on the patterns employed fifteen or twenty years ago. The high perfection to which the modern electric generator and motor have been brought certainly demonstrates that when care and application are given, good results may be obtained. This line of dynamo-electric machinery can, therefore, certainly be much improved beyond its present standing, and the result should be a type of electro-plating machine that will take its rank with the modern electric light and power generator.

With the almost universal adoption of the electric light have come many advantages which only recently were considered necessary evils of a printing office, such as poor air, overheated atmosphere, and bad odours, especially in those in which much night work had to be done or where, for any reason, the light was not sufficient during the daily working hours to permit dispensing with artificial illumination. Where illuminating gas is used, the light is seldom steady, but has a persistent flicker, exceedingly trying to eyes which are frequently overtaxed with poor copy. In many composing rooms the heat generated by the gas jets, which are necessarily close to the



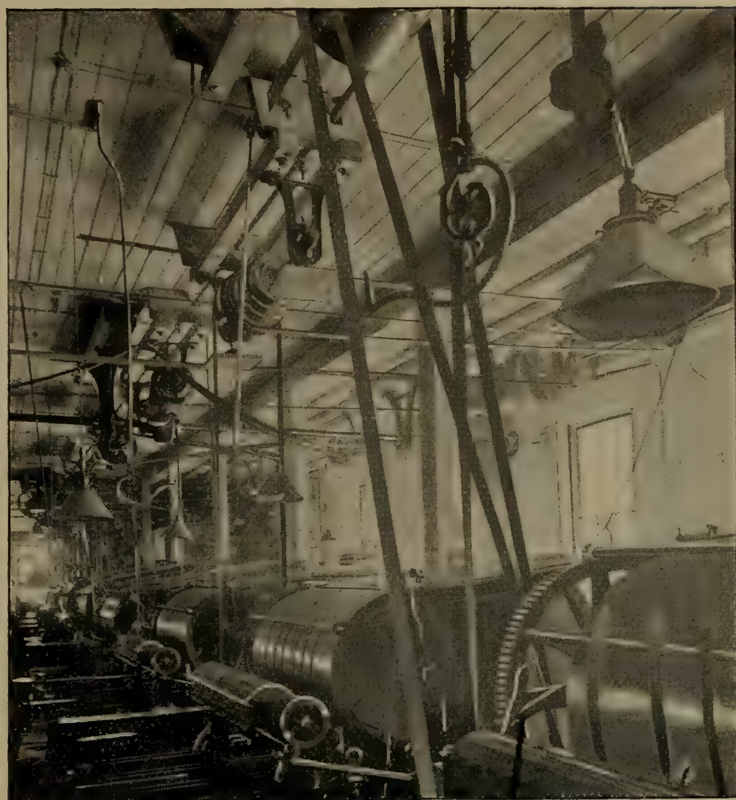
A SPRAGUE ELECTRIC PRINTING PRESS EQUIPMENT

heads of the compositors, becomes so oppressive as to seriously interfere with the amount and character of the work of the employees. An atmosphere largely deprived of its oxygen and further vitiated by the heat produced by the use of gas as an illuminant, is practically eliminated by the substitution of the electric light.

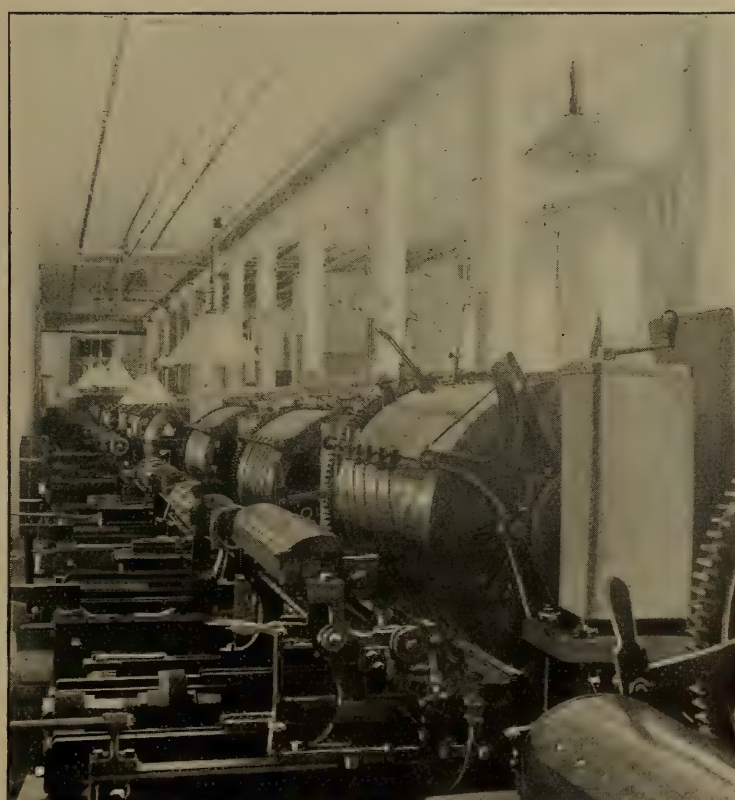
It is of the utmost importance that light in a composing room should be uniformly distributed, not brilliant in some places, with intermediate shadows or dimly lighted sections. The latter is the case where arc lighting is employed, with the rare exception of a combination of the inverted arc and a plain ceiling for its reflection, free from all overhead obstructions and supporting columns within the working space. When incandescent lighting is properly installed to meet the requirements demanded by the composing case, maker-up, imposing-stones and floor hands, shadows should be entirely absent.

But the most distinctly advantageous application of electricity in the printing office is found in the use of the electric motor for driving its machinery. During the year 1894 the first attempts at individual attachments of the electric motor to printing presses were made, and proved sufficiently encouraging to warrant an attempt to establish this method of press driving in a manner that would definitely relegate the belt drive to the past.

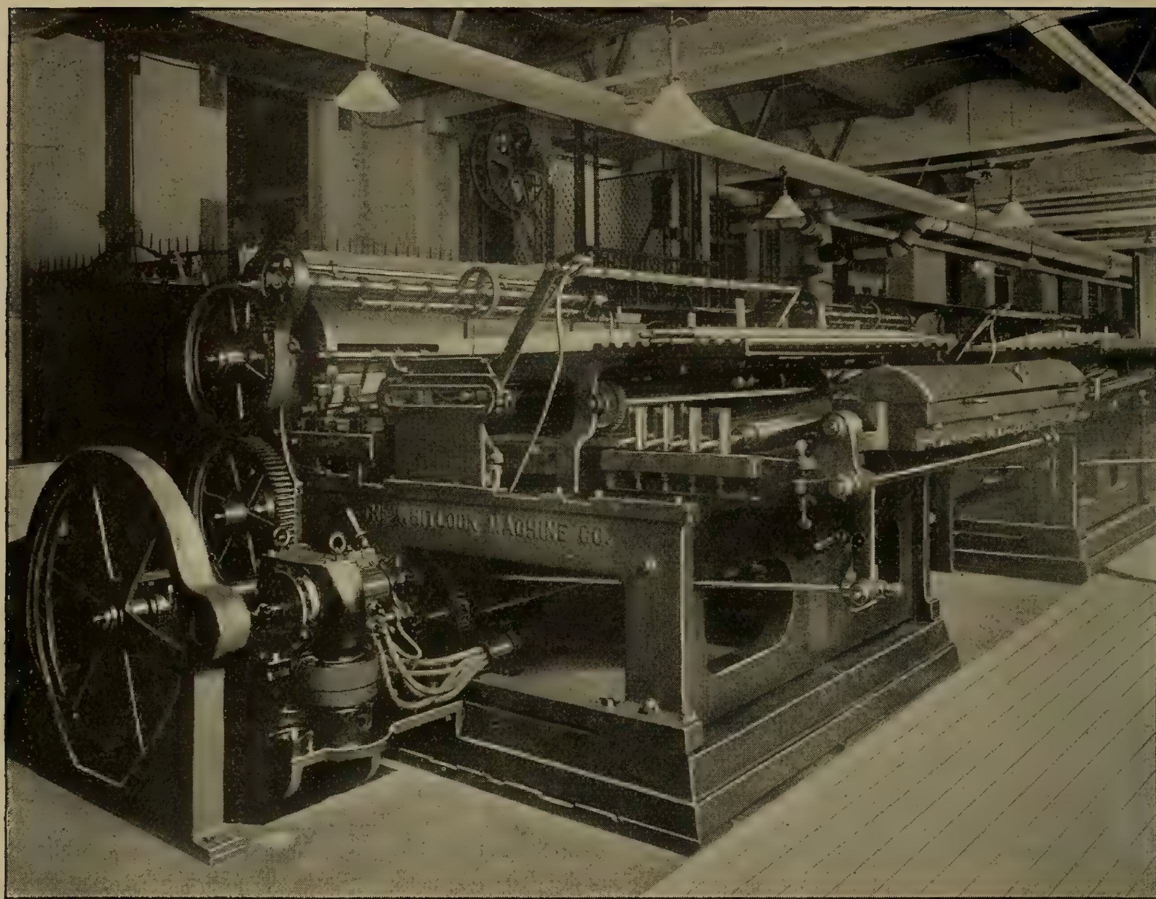
Encouraged by the first indications of success and the wide fields of labour



A ROW OF PRESSES DRIVEN FROM OVERHEAD SHAFTING



THE SAME PRESSES DRIVEN BY INDIVIDUAL GEARED ELECTRIC MOTORS, SHOWING ALL SHAFTING REMOVED



A GOOD EXAMPLE OF PRINTING PRESS EQUIPPED WITH A 3 H. P. GEARED CROCKER-WHEELER MOTOR

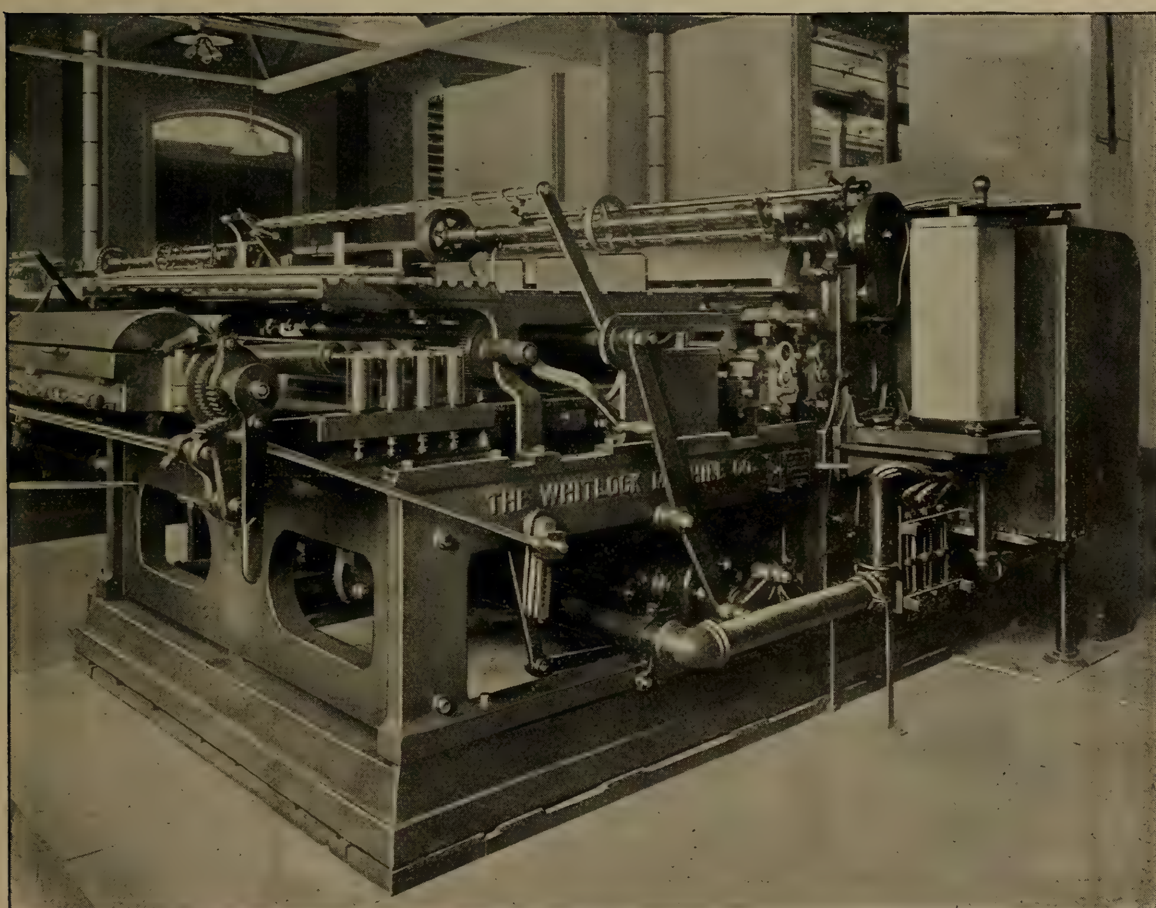
that this one industry afforded, electrical manufacturers and engineers started at this problem with the assumption that theirs was the vital and most important side, scarcely giving a thought that they were only a means towards an end and not the end itself, losing sight almost entirely of the fact that the printers wanted printing done which should be in every way equal to that of the steam-driven printing press, with sufficient advantages to warrant the increased cost, and not that the printing office existed principally as a market for the sale of electric motors and accessories. Nearly two years of hard work, resulting mostly in mediocre success when not failures, were necessary before it became sufficiently clear to electricians that to obtain a success that would justify printers in adopting the electric motor as their motive power, a different method of solving this problem must be found than that followed up to that time. When this was once appreciated and time was given to studying the requirements of a printing press, how best to attach the motor mechanically to the press, where to locate the controller so that it would be as convenient as the old belt shifter, the way was paved in great part for a solution that has proven mutually advantageous to the printer and the electrical industry at large. In general, the advantages of electric driving for printing presses may be grouped under the following heads:—Decrease in power consumption, location of machinery irrespective of main line shaft, increased product, efficient control, and lower cost of maintenance and operation of the plant as a whole.

Careful tests have shown that the friction load, when driven by steam, of the shafting in a printing office varies anywhere from 30 to 70 per cent., depending upon the number of presses in use and how they are located with reference to the main line of shafting. A safe estimate for most offices of ordinary

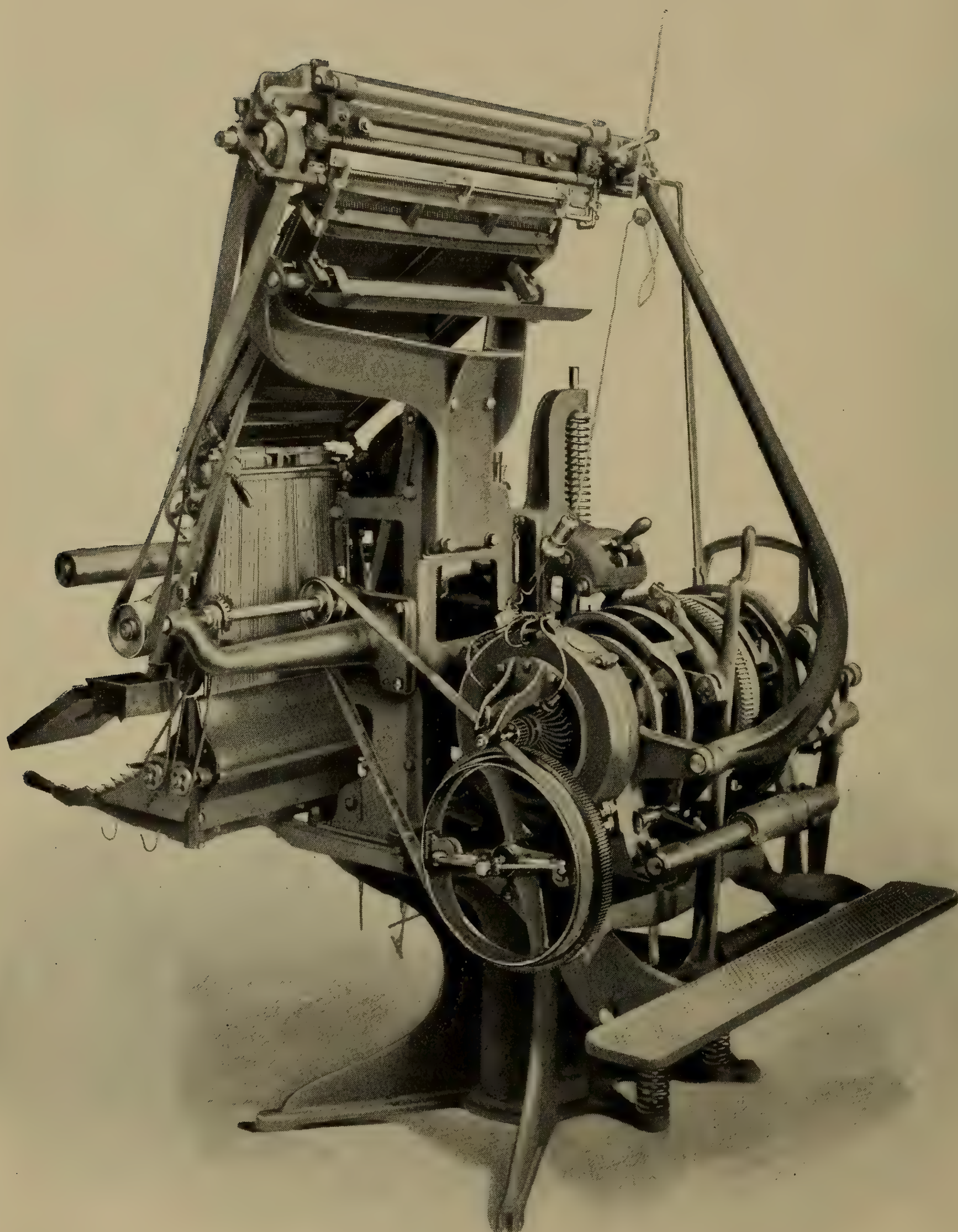
size can be placed at 40 per cent., which should mean a saving of about $500 (£100) per annum, when figured on a 6 per cent. basis. This represents an investment of $8,333 (£1666), which amount of money will pay for the complete electric installation for twenty-five printing presses using two, three and five horse-power motors with best types of controllers, rheostats, and circuit breakers. The average cost, including attachment of motor to press, done in a most workmanlike and substantial manner, should not exceed $325 (£65) for each printing press; this is for the standard geared type motors. A printing office of moderate size can thus afford to displace all the steam fixtures with a modern individual electric equipment, for the saving in power will, as shown, more than pay for this investment on a 6 per cent. basis.

The ability to locate machinery irrespective of a main line shaft is peculiar to the individual motor equipment, and its great advantages are more clearly seen and appreciated to-day than they were several years ago.

With the new arrangement it is not necessary that the presses should be close to the source of power or that the ceiling should be one to which heavy hangers and shafting can be secured. Each piece of machinery with its self-contained motor necessitates the consideration of one thing only, that of floor space. In the bindery and foundry this permits of the placing of machinery so as to reduce handling of material to a minimum, which is prohibited by the belt drive, owing to the overhead pulleys and belting necessary if machines have to be placed at right angles to the main driver. This trouble is still further increased when machines, side by side, run at widely different speeds,—a metal saw, for instance, running at 6000 revolutions per minute, while its



A VIEW OF THE OTHER SIDE OF THE PRESS, SHOWING THE CONTROLLER AND THE WIRING BETWEEN MOTOR AND CONTROLLER, LED THROUGH IRON PIPES



A SPRAGUE ELECTRIC COMPANY MOTOR, GEARED TO A LINOTYPE MACHINE

companion may be a slug machine or shaver, operating at 80 or 100 revolutions.

Anything that will permit of an arrangement whereby machines can be located with reference to one another so that, without increasing their speed, the output of the establishment can be increased, without extra expense, by even a small percentage, will make the gain very noticeable at the end of the year. In many offices this amount has been from 10 to 20 per cent.

The absence of overhead shafting and belting does away with the spoiling of paper from oil and dirt, which, at times, will come down even when great care is taken. The light, too, is much better and the atmosphere purer where overhead belting is absent, all leading to a higher grade of work with increased output.

Experience has shown that for this class of work a cumulative compound motor gives the most satisfactory results, the control to be by armature resistance to normal running speed, and the higher range of speeds to be obtained by weakening the field of the motor, for which an external resistance with a large number of contacts should be provided and connected in series with the field circuit. The controller should have six forward gradations, with two for reverse, these circuits being so arranged as to cut out the series winding when the handle is in the "full on" position, leaving the motor a plain shunt motor which can have its speed still further increased by weakening the field through the field regulator already provided. The function of the cumulative series winding is to provide a stiff starting torque for proper handling during "make-ready," together with the ordinary starting of the press.

This, with a stiff field, has been found more satisfactory, at the same time using less current for ordinary two-revolution printing presses, than a constant field in the motor, whether the press is running or idle, the controller in the former cutting off all current to the motor when in the off position. The plain shunt motor, having its field always in circuit whether the press is in service or not, will consume 10 to 15 per cent more energy to do the same work during the day than when the compound cumulative winding is used. These are average conditions as met with in commercial work, but would not hold good if the presses were constantly on long runs, where "making ready" occurred only at infrequent intervals.

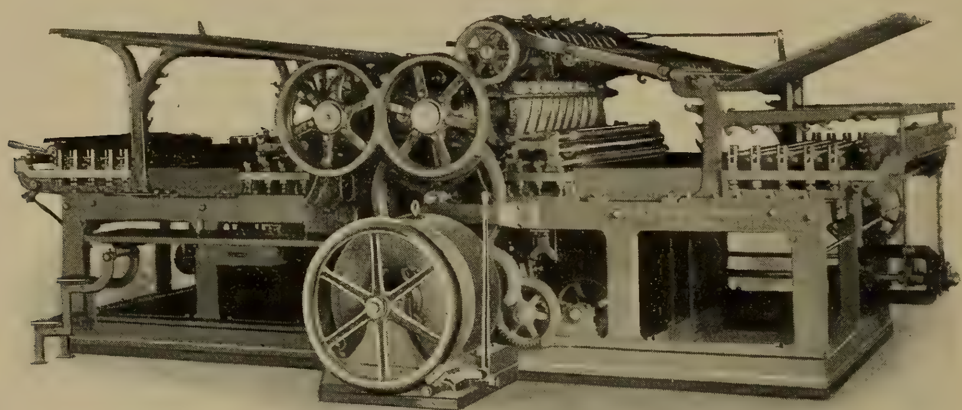
The above method of control has been found to give the best results for the handling of presses and economy of power used to operate them for a given amount of work performed over that of the series motor having commutated fields for its speed variations, the plain shunt motor, or the compound motor using a commutated field winding.

To properly determine the size of a motor for a press, the one thing to bear in mind is to have it large enough to start it, no matter in what position the press bed may be. This tends largely to reducing to a minimum the non-productive period. The motor should be wound to have its highest efficiency at about three-quarters full load, as experience has shown that the majority of presses operate at from 60 to 75 per cent. of the rated capacity of the motors best suited to their use.

The question as to whether the geared or the direct-connected motor should be adopted for printing press work is still a disputed question, both types having distinct advantages, but neither containing all. Compactness and noiselessness are the principal advantages of the direct-connected types. Their speed necessarily cannot be standard, but must conform to the press which they are originally intended to operate. The bore of armature and supporting brackets, or sub-base, must be special for each size and style of press. Their cost is generally twice that of a standard, moderate-speed, geared motor.

The disadvantage of the geared motor is principally that the ratio of gearing made necessary by the speeds of certain makes of presses is such that it is practically impossible to run without noise. This, with the difficulties of securing a substantial mechanical connection be-

tween the motor and the frame of the press, is more than offset by first cost, the fact that all motors of the same horse-power are uniform throughout permitting an interchange of parts, thus reducing delay, in case of injury to motor, for repairs to a very short period, while stoppage of press with a direct-connected motor might result in loss from idleness of press exceeding the entire cost of a standard geared equipment.



A BULLOCK MOTOR CONNECTED TO A COTTRELL PERFECTING MAGAZINE PRESS AT W. BUXENSTEIN'S, BERLIN, GERMANY

The geared motor has the further advantage that when disconnected from an old press it can be applied to a new one of the same size, but of different make, irrespective of size and speed of the press shaft, which might vary so much as to make it impossible to again use a direct-connected motor without entirely rewinding it at a cost greatly in excess of that caused by changes needed with a geared motor, namely, that of gearing to suit the new press. Most press builders will provide this in lieu of the countershaft furnished with old steam, belt-driven presses. The cost of current for doing work, all things being equal, on sizes from 5 H. P. to 10 H. P. is about on a par. With from ½ H. P. to 3 H. P. it is in favour of the geared motor.

The cost for operating presses electrically should always be less than under the old belted system. This, however, is a small item compared with the beneficial results derived from the individual equipment which gives independent drive and control to each press, and constant speed under all conditions as applied to the main press shaft, thus producing a more uniform and higher grade of work. Experience has also shown an increased output of from 5 to 15 per cent., those offices working their presses the most steadily receiving the greatest benefit.

The combined cost of maintenance of press and motor under the above conditions is less than with the old belt drive, the motor requiring little or no attention aside from keeping the commutator clean and the carbon brushes properly fitted. This can all be done for the same cost as looking after the shafting and belting. The writer's personal experience has been, with the introduction of the electric drive applied to printing presses, that the cost for repairs to the latter have been less and the presses out of service less on this account than before using this method.

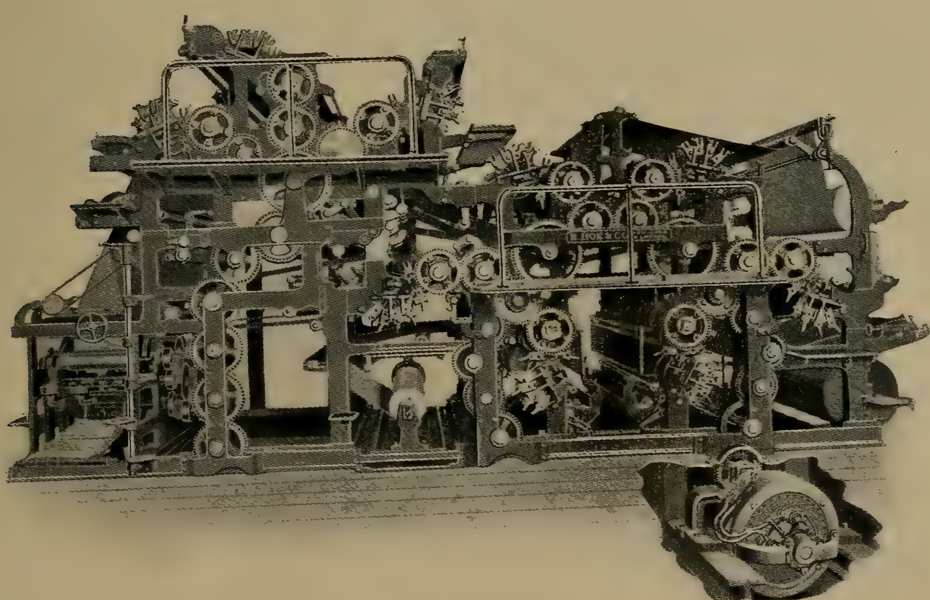
There are good printing presses and there are poor ones; yet profitable results can be secured only from high-grade machinery, honestly made and properly designed to meet all requirements now demanded by the printing art. For this class of material an adequate compensation must be given. So with the electric equipment, if all the benefits are to be derived therefrom, the

printer must be guided by the same methods of reasoning that he follows in purchasing his printing machinery.

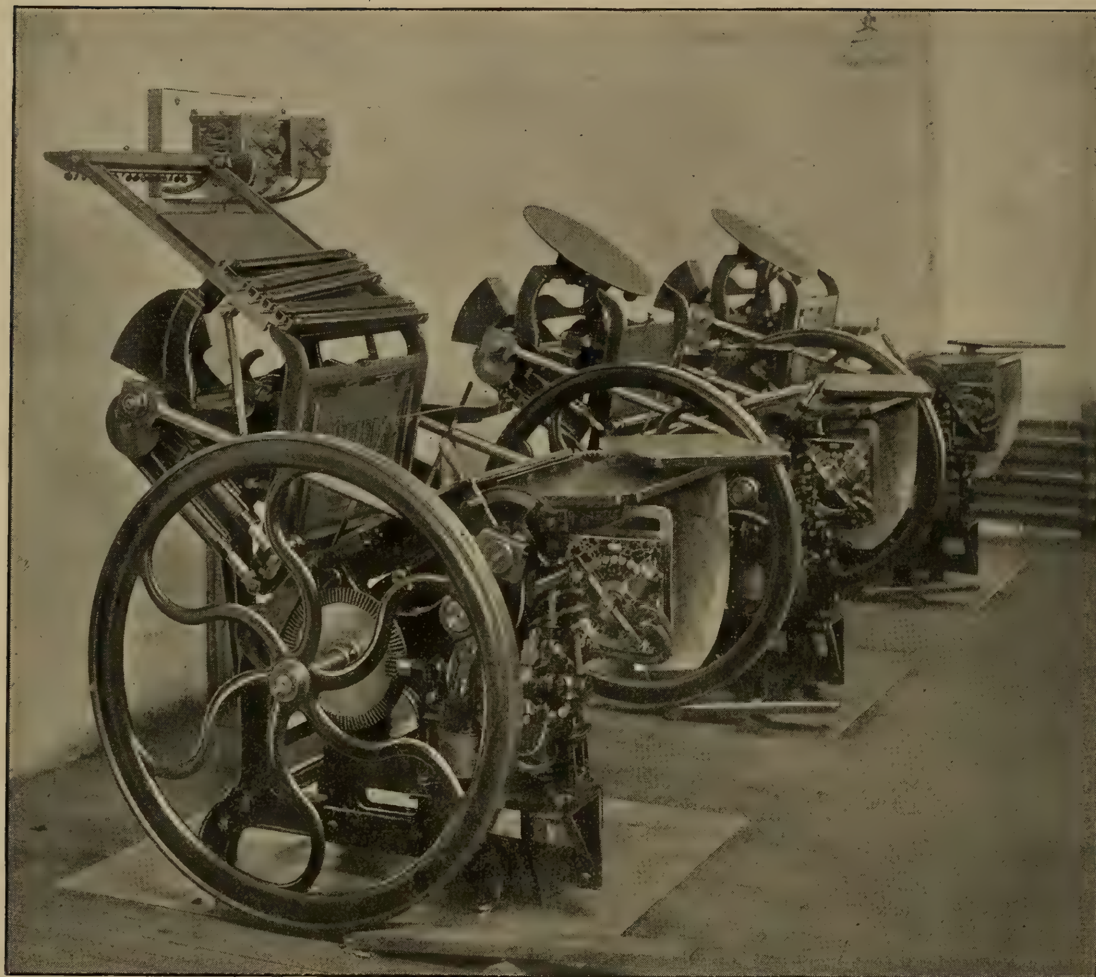
Only that grade of motors especially developed to meet these requirements should be considered, and their cost is usually higher than those not thus designed. The lowest first cost is frequently the most expensive in the end, as an improperly designed motor will invariably cause many stoppages which will soon amount to more than its entire first cost. The accessories needed with each motor are few, but must be of the same high grade of material and design as the motor itself. These should always include rheostats, controller, and circuit breaker. The rheostats must be able to carry the full current of the motor without injury. The controller must be compact, with ample carrying capacity in all contact surfaces, with a quick make-and-break contact, and preferably of the cylindrical or barrel type, similar to that used in street railway service. The use of the circuit breaker is not only a safeguard to the motor, but is a great protection to the machinery as well, preventing rough handling, thereby giving longer life with less repairs. To this device, more than any other, is attributable the lessened cost of maintenance of machinery in the electric drive over that of the old method of belting.

The work of installation is largely mechanical, and failure to realise this has caused many of the failures in the pioneer work. The most important feature is that the motor must be attached to, and become a part of, the press, and this should be accomplished without an increase of floor space or in any manner interfering with the pressman's ability to handle the press. This part of the machine work ought to be done as carefully and substantially as any connected with the press, otherwise it cannot give the satisfactory results that should be obtained. The location of the controller should be given individual consideration for each type of press. The controller should be substantial, located within easy reach of the feeder or pressman, and so placed as not to interfere with the accessibility of all adjustable parts of the press.

The electric wiring between motors and controller ought always to be of the highest grade, using the best quality of insulated wire, which should invariably be placed in iron pipes, thus protecting it from mechanical injury and the deterioration which will result from being exposed to printer's ink, oil, and benzine used about all presses. Wir-



A BULLOCK MOTOR DRIVING A HOE SEXTUPLE PRESS



A ROW OF SELF-CONTAINED PRESSES, EACH WITH ITS OWN INDEPENDENT MOTOR

ing, properly done, will give absolutely no trouble. This has been tried for a sufficiently long period so that results can be guaranteed when proper care and materials are used. The writer has had wiring done under his personal direction for several hundred motors during the past five years in accordance with the methods advocated above, and not one has as yet given any trouble. Every motor's record is kept, and so far the maintenance for wiring has no charge against it.

The question whether individual or group drive gives the better results in bindery work largely rests with conditions of each office. The machinery used is generally so light that the power actually required for it is small. If the question were simply one of power consumption, and that machine which consumes the least were to be the guide in determining the character of the drive, the group drive should be unhesitatingly selected, as it is decidedly more economical from the standpoint of power consumption. Sewing machines, wire stitchers, ruling machines, stabbing machines, folders, case-making machines, and others of the same class require motors of from 1/6 to 1 H. P. These small sizes, owing to their low efficiency, cannot be operated nearly as economically as large-size motors belted to a line shaft, with properly grouped machinery having the effective work proportioned to the motor so that the latter can practically operate most of the time at its highest efficiency.

The first cost of the individual drive is much higher than that of the group drive. Its advantages are individual control and ability to place machinery wherever desired, affording the opportunity of decreasing the labour of handling during the different stages of manu-

facture, with an increased output per square foot of floor space without additional cost. This has been found so much in some binderies that the increased output has more than paid for the entire electric equipment in two or three years.

The prospects of electricity superseding both steam and gas for heating in the various branches of bindery work are very bright, as the results thus far obtained indicate its superiority in every way. The heads for embossing and stamping presses, and heaters for finishing tools and glue kettles have received a sufficient commercial test to prove their worth.

The superiority of the electric press head is that the heat is concentrated directly at the point of work, and the gradations of heat are such that they can be made whatever is best for the kind and size of work in hand. The principal objection to the steam head is the inability to control temperature and to always drain off all condensation. This is likely to cause certain parts of the head to be lower in temperature than others. When this happens on any part of the impression, the work lacks clearness. Since the introduction of electricity as the heating agent better work and more of it, with less waste, has been the result, and the atmosphere of the room is much better where many machines are operated than under the old régime.

The heating of finishers' tools is as yet accomplished from external sources and not confined to the tool itself. Owing to the peculiar shape of many of these, the individual application has more disadvantages than advantages. At the present time, heating of these by gas is more economical and satisfactory for the general run of work.

Electric glue heaters can be placed on each workman's bench, and heat can be so applied that the glue will always be in condition for use. This saves the time necessary to carry back and forth glue kettles from a large steam heater, and also permits of individual tempering of glue to suit work in hand without any loss of time. But the cost of electric current is still too high to make individual electric heating an economical competitor of gas.

A VIEW OF A JOB PRESS ROOM, SHOWING ECONOMICAL USE OF FLOOR SPACE IMPOSSIBLE WITH BELT DRIVE

CONTINENTAL STEAM ENGINE PRACTICE

SOME BRITISH OBSERVATIONS AT THE PARIS EXHIBITION

By W. D. Wansbrough

NEVER before in the history of steam-engineering has an opportunity presented itself such as now exists, in the vast collection of prime movers on view at the Paris Exhibition, of comparing with our own the practice of French, German, Swiss, and Belgian competitors.

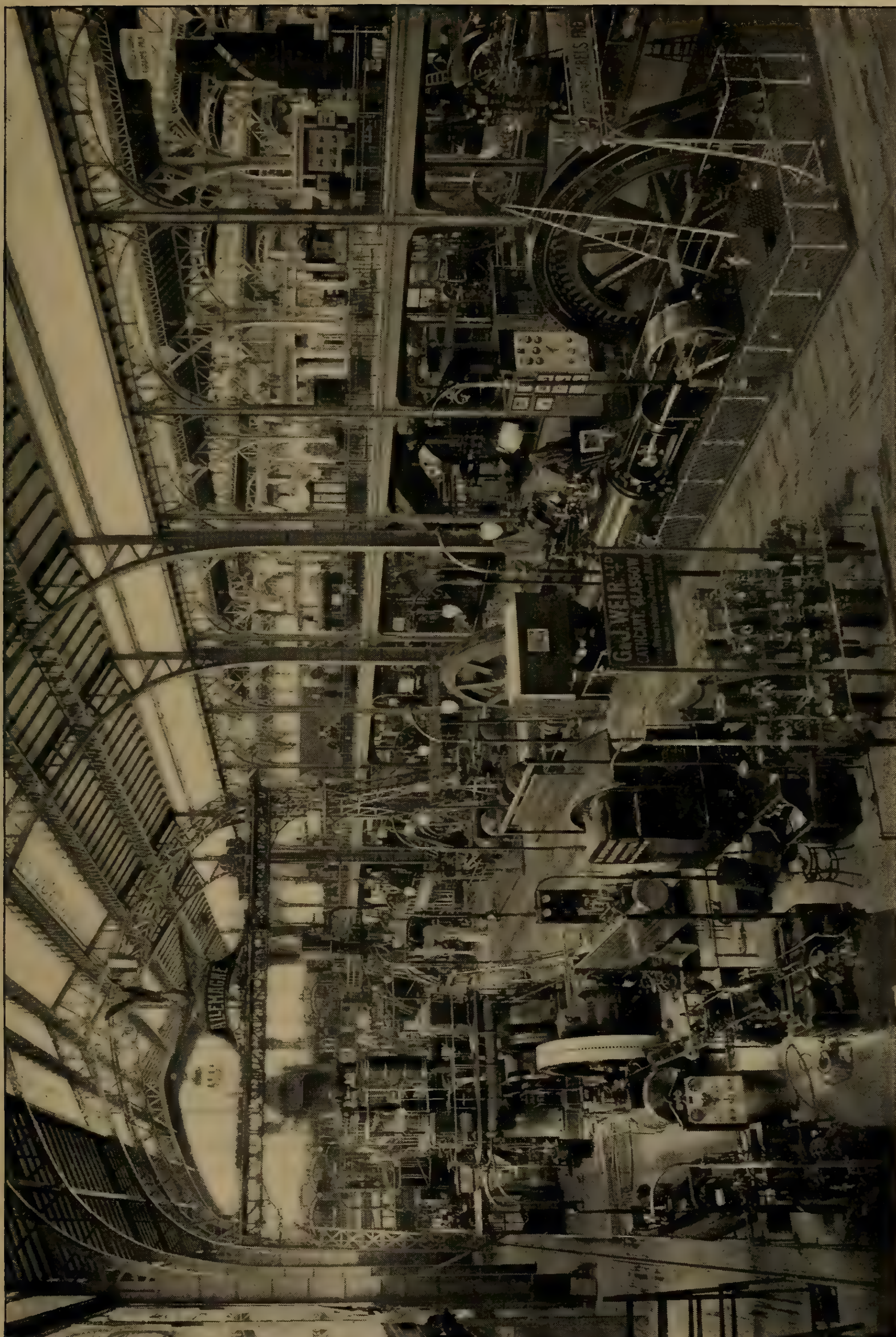
The imposing array of Continental steam-engines in the Palais de l'Electricité compels the undisguised admiration of every visitor. The long lines of huge black engines, each with its direct-coupled dynamo, stretch from end to end of the great building, and, whether in repose or in dignified movement, produce an impression of concrete power not likely to be soon effaced. Each colossal unit seems to be conscious, as it noiselessly and almost lazily extends and withdraws its bright arms, of overmastering strength. It seems to say:—"If you choose to reckon me in terms of your pitiful animal units,—well, I am 1000, or 2000, or 3000 horse-power," as the case may be.

But we are in the presence of another force before which even these monsters may struggle in vain. Surrounding the periphery of each fly-wheel are disposed certain magnets, and coils, and plates, —not particularly in evidence, making no pretension of any kind, but still there. Now, put but certain brass surfaces into contact by the movement of a lever, and you shall see the sweat gathering upon the brow of Hercules, as he strains to turn his wheel; and his attendant mortal breaks our reverie by exclaiming:—"It's no use, Sir; he has had enough. I must switch off again, or we shall break something."

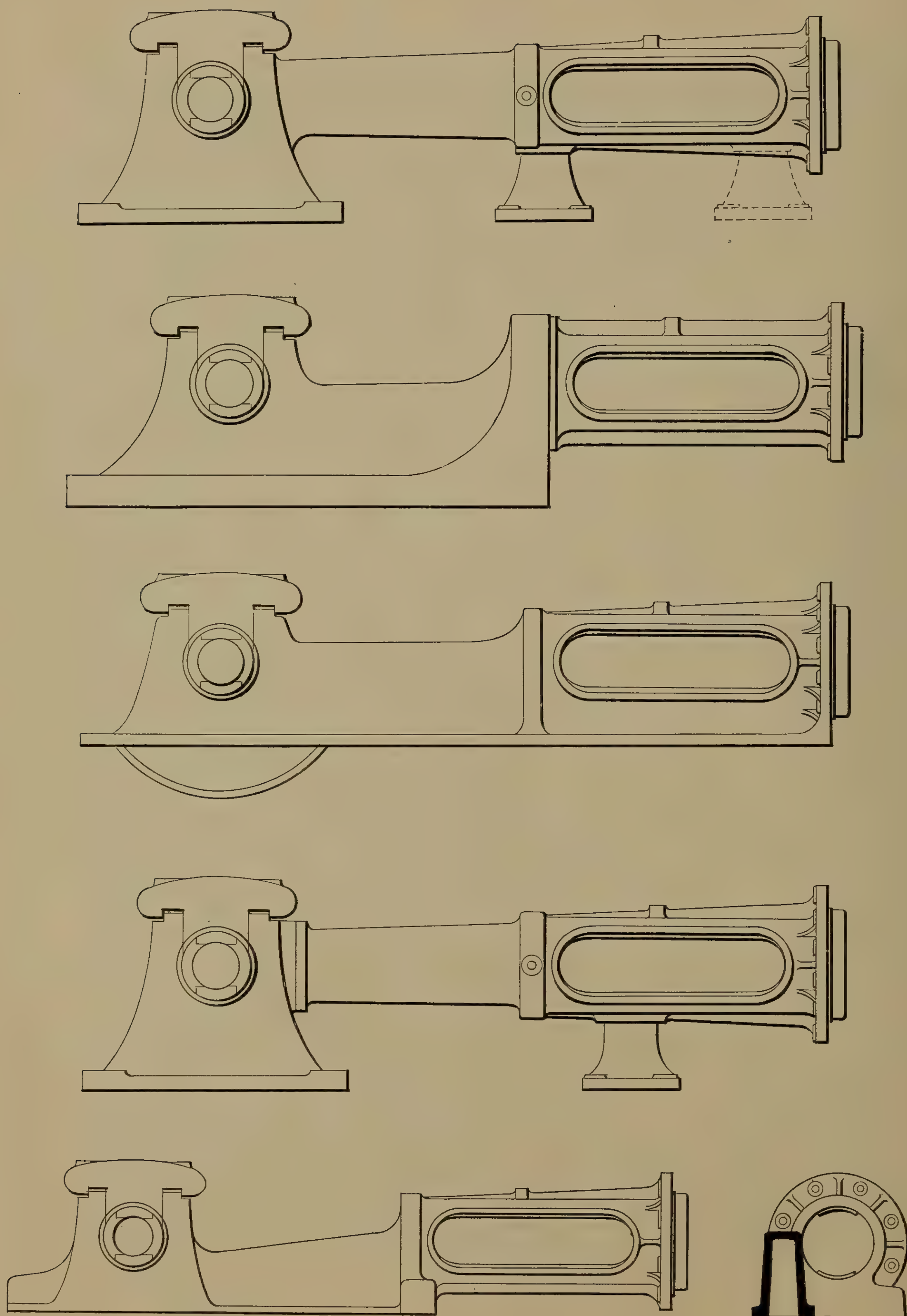
It is in honour of this unseen force that the sumptuous building in which we stand has been erected. The nations of Europe have sent hither of their best with ungrudging hand. Side by side in this spacious temple stand the long rows of shining engines, the guests of the Republic of France, who herself, from her great foundries of Creusôt, and Lille, and Rouen, with a score of others, sent a great assemblage of their equals in rank to bid them welcome.

Here France and Germany, Russia and Italy, Switzerland and Belgium, the dual empire of Austro-Hungary, and the little kingdom of Holland meet on neutral ground, and vie with one another in this grand review, this summing-up of the century's work in the field of mechanical science. And Great Britain, —the birthplace and cradle of the steam-engine,—she is, of course, represented upon a scale commensurate with her political and industrial importance? All the Continental nations learnt their trade in steam-engineering, in a greater or lesser degree, from Great Britain; and she has, no doubt, taken care to show the cosmopolitan crowd which throngs the Paris Exhibition that the British shops are still at work?

There is no use in gilding the pill which the British engineer who visits the Exhibition will have to swallow. Whether certain political events, occurring coincidently with the time for making entries for the Exhibition, affected the question, it is difficult to say. It is equally difficult to avoid a feeling of bitter disappointment, amid all this display of Continental talent and business enterprise, to find that out of all the numberless manufacturers of steam engines in the British Islands three only have taken a share in furnishing the power required for the ex-



A VIEW OF THE FOREIGN SECTION IN THE PARIS STEAM ENGINE EXHIBIT



FIGS. 1 TO 5.—SOME TYPES OF ENGINE BEDS

hibition, the firms of Willans, of Galloways, and of Robey, in co-operation, respectively, with the three electrical firms of Siemens Brothers, Mather & Platt, and Scott & Mountain.

The first thing which strikes the observer about the Continental engines is the way in which they are almost uniformly finished off in what may be called an "arrangement in black and silver." Seen in repose, these monsters present an appearance of sombre, almost mournful, dignity. The effect is very fine, and it appears to be produced by coating the castings,—previously, of course, carefully smoothed,—with an inexpensive composition known as "Berlin black." Practically there is no brass work visible, all the oil-pipes, lubricators, etc., being made either of white metal or being nickel-plated. In many of the engines the whole of the polished work, from the connecting-rod and crank-arm downwards, is nickel-plated, and not infrequently the nuts also, instead of being left black or grey from the case-hardening,—which would not look well on a jet-black ground,—are polished and nickel-plated, like enlarged copies of those used by bicycle makers. It should be understood that bright work in the shape of polished ribs or mouldings is sparingly introduced, the polish being more conspicuous by its quality than by its frequency.

The covering or lagging of the cylinders is in most cases elaborated to a degree never seen in British engines. The blued steel or Russian iron employed is much thicker and stronger than that we are accustomed to use. It is carefully fitted into the corners, and is secured either by cast-iron turned bands of moulded section, or by nickel-plated straps of iron or steel, with deeply bevelled edges. Again, to take one example out of many, the 1000 H. P. tandem engine of Carels Frères, of Ghent, stands like "a mansion in its own grounds" in the midst of a great plain of admirably fitted wrought iron chequered floor-plates, all black-finished to match the engine. None of the British engines is seen to such advantage. Every one who knows Willans, and Galloways, and Robey knows also the sterling qualities of their machinery. But their engines are outwardly at a distinct disadvantage as compared with those of their Continental neighbours. One brilliant exception to the general blackness is the 1000 H. P. cross-compound engine of H. Bollinckx, of Brussels, which is painted a blazing scarlet,—a departure which does not commend itself on the score of good taste.

All this may appear trivial and unworthy of the attention of the British manufacturer. No doubt it was so, in the days when British steam-engines and machine tools were the best in the world and everybody knew it, in spite of what we are now forced to consider a lack of that outward finish which our competitors are only too ready to put on.

Taking the horizontal engines first, as befits their importance, we note that trunk beds are universal. These are, however, of varied construction, but may generally be resolved into one or other of the forms outlined in Figs. 1 to 5. In the majority of cases the cylinders have the end portions, containing the steam and exhaust valves, formed into feet or pedestals by which the cylinder is attached to the foundation, the trunk taking no part in carrying the cylinder. No case of an entirely overhung cylinder occurs in any large or even moderate-sized engine, though occasionally the outer end only is supported, the bed being provided with a foot underneath the flange uniting it to the cylinder. The end of the trunk guide nearest the crank is always supported,—as it should be. In British engines this is not invariably the case.

In some instances the feet or supports seem to be rather overdone. Thus Dujardin & Cie., of Lille, have a small engine with the whole length of cylinder supported, a foot under each end of the trunk, and a massive support under the main bearing. Bollinckx and many others cut away the front of the trunk casting, leaving a bright edge of fantastic outline, unpleasant to the British eye (Fig. 6). Dujardin also forms the main plummer block separately from the

bed, with a faced and bolted joint, as shown in Fig. 7. Some other makers follow this practice,—which amounts to an admission that the casting, as a whole, is too large for them to handle,—but strive to conceal the joint, the bolts or screws being evidently tightened up inside the hollow plummer block. This would involve lifting the shaft and fly-wheel out, should the joint ever work loose, and is for every reason to be condemned. Garnier and Faure-Beaulieu, of Paris, for reasons best known to themselves, go to the trouble of planing or milling out the trunk guides in V-grooves, the only exception noticeable to the usual practice of boring out the guides in circular form.

The main bearings of all the large engines in the exhibition are of the pattern shown in Fig. 8, and of most massive and solid construction. The "brasses,"—usually of cast iron lined with Babbitt metal,—are set up, as a rule, by side wedges, drawn up by nuts on the top of the cap, though in a number of instances large set-screws placed horizontally (as shown dotted) are used in place of the outer pair of wedges. Although the actual plummer blocks, or main pedestals, are massive enough, the diameter of the shaft in most cases appears rather small, in view of the heavy alternator wheel, or armature, which it has to carry. Occasionally, also, the shafts seem needlessly long for the actual requirements. The disc shaft of the only British horizontal engine at work appeared to be proportionately much the largest in the exhibition.

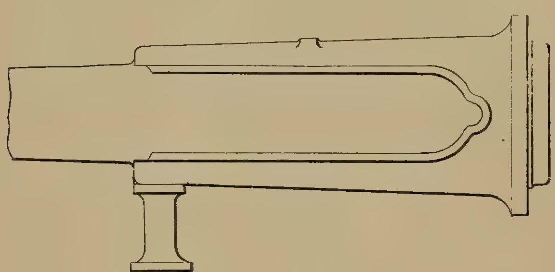


FIG. 6

Opinion on the subject of crank discs *vs.* crank arms for horizontal engines seems in Great Britain to be about equally divided. French makers, as judged by their exhibits, seem to be in favour of discs of cast iron. One French firm, Weyher & Richemond, show discs of cast steel of a peculiar pattern, of which more presently. Outside the French and British sections wrought iron or steel crank arms, finished bright all over, seem to be preferred. Many of these have large balance weights forged solid with them. It is worth notice that in the large vertical engines by Sulzer, Borsig, the Augsburg-Nürnberg Company, and Ringhoffer the cranks are placed opposite, *i. e.*, at 180°; and these engines run with a smoothness not attained by the Allis type vertical engine of the Société Française de Constructions Mécaniques.

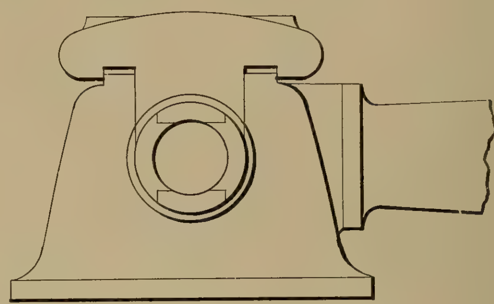


FIG 7

One four-cylinder triple horizontal of 1200 H. P., by Franco Tosi, of Legnano, Italy, has a very long two-cranked shaft with five bearings. These cranks are built up as in marine practice, but have balance-weights forged on. The cylinders are arranged double, tandem-fashion, and are placed as closely together as possible, attached to a sort of twin trunk bed. The high-pressure and

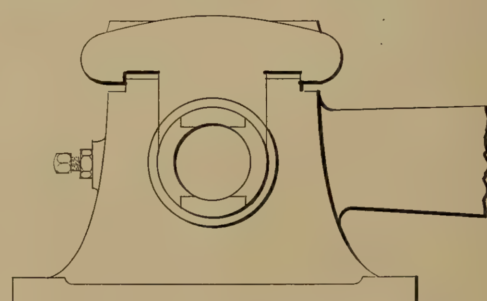


FIG. 8

intermediate cylinders are placed side by side next the crank, with the two low-pressure cylinders behind them. In all the other compound or triple engines with the cylinders placed tandemwise, the larger cylinder is put next to the engine bed. This arrangement pos-

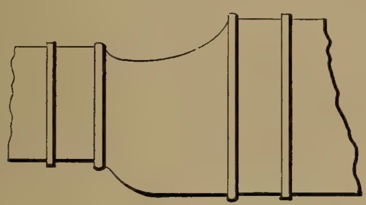


FIG. 9

sesses many advantages, but amongst them facility in removing the line of pistons cannot be reckoned. So much importance was formerly attached to this feature that in Great Britain, at any rate, the smaller cylinder was almost always placed next the bed, and not infrequently sufficient space was allowed between the two cylinders for a coupling connecting the two piston rods. This, of course, entailed an addition to the length of the engine equal to the stroke plus the length of coupling.

The connection between the two cylinders in the Continental tandem engines usually takes the form of a large shell-like casting (Fig. 9) large enough for a

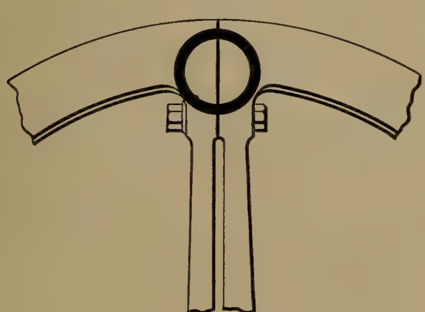


FIG. 10

man to get inside and take off the cylinder covers, and then draw either piston outside its cylinder for examination. To remove the pistons altogether must be a formidable task under this arrangement.

In some of the larger engines the bolts or studs uniting the low-pressure cylinder to the flange of the trunk bed are as much as eighteen inches apart from centre to centre. No doubt the makers find their account in adopting these extraordinary pitches, but it implies immense depth and strength in the flanges so connected, needlessly in excess, one would think, of the actual requirement were a lesser pitch employed.

In most engines of any size the cylinder covers are steam-jacketed, being cast hollow or cellular for that purpose. As the value of jacketed surface for engines working at such rates of expansion as those in the exhibition is unquestionable, jacketing the covers as well as the barrels of the cylinders should logically be followed by heating the pistons also by live steam, about which no

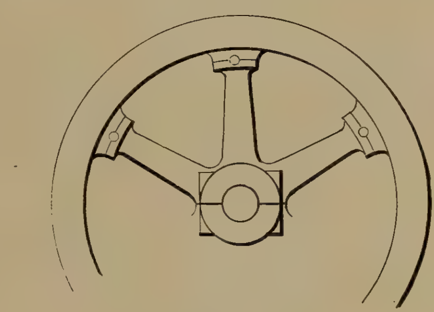


FIG 11

difficulty has been found in practice. In some cases the whole of the steam supplied to the engine passes round the cylinder before reaching the stop-valve. This plan is adopted, amongst others, by the firm of Sulzer Brothers, of Winterthur, Switzerland.

Every engine at work in the exhibition, without exception, exhausts into a condenser of one form or another,—a wise provision on the part of the administration, as previous experience with exhaust mains in cases of this kind has not been satisfactory. Steam is supplied at 140 pounds pressure, and there is an abundant supply of cold water laid on. There is not a steam leak to be seen in the exhibition; in fact, the engines might be electrically driven for all the evidence there is to the contrary. Horizontal condensers, worked by a tail-rod, are represented only by one or two examples

in the whole show. Most of the engines are fitted with vertical air pumps below the ground level. These are mostly placed alongside the trunk in plan, sometimes with the rocking lever worked by a short connecting-rod from the cross-head pin, but quite frequently the air

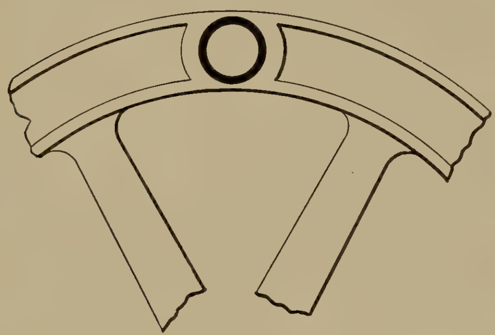


FIG. 12

pump is inclined and has the same stroke as the engine, the connecting-rod being worked direct from the crank-pin. In only two or three cases are the vertical condensers placed behind the engine and worked by a rocking lever from the tail-rod.

Fly-wheels generally are by no means so heavy as we should expect in view of the increasing attention paid to uniformity of rotation nowadays. The French section especially contains ex-

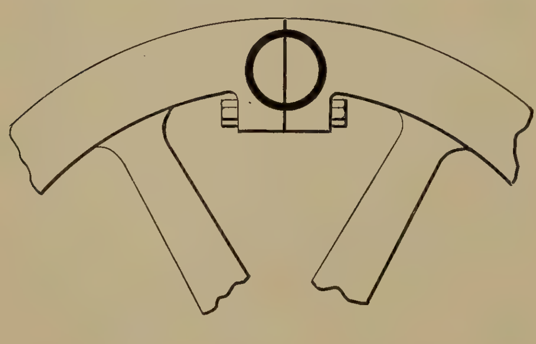


FIG. 13

amples of wheels manifestly unequal to their work. In one case,—not one of the driving engines,—attempt after attempt was made to start the engine without success, owing to the too light fly-wheel employed, which could not be induced to carry the crank over the dead centre.

Of the usual British pattern of built-up fly-wheel,—consisting of a heavy boss with cottered-in arms, secured by flanges to the segments of the rim at their joints,—there is not a single example in the exhibition; but otherwise the number of different constructions visible appears to comprise all the possibilities in this particular branch of engineering design, and may be summarised thus:—

Franco Tosi, Legnano, Italy.—Wheel in halves; bolts at boss; splice plates at sides of rim; shrunk-on oval rings under rim. Weyher & Richemond, Pautin.—Armature wheel split along pair of arms; bolts at boss and rim, and at centre of arms; oval hoops shrunk on large boss at junction of arms and rim. Société Française.—Allis pattern, vertical 65-ton wheel, 23 feet diameter; in ten segments, each with its own arm cast on in centre of its arc,—not to be commended, as it leaves the joints weak against bursting stresses,—shrunk-on rings uniting rim sections; spokes gripped between large collars on shaft, and bolted through.

Lāng, of Buda-Pesth, and the Erste Brunnen Gesellschaft each show engines with alternator wheels by Ganz, in halves, double arms bolted at boss, bolted also under the hooped projections uniting rim-joints, as shown in Fig. 10. The Actien-Gesellschaft Maschinenbau Braun show a solid rim, cast separately from arms, the spider in halves, every arm fitted to seating on rim, as seen in Fig. 11. Dujardin, of Lille, shows one-half only of a rope-driving fly-wheel upon a 2000 H. P. horizontal. Diameter, about 24 feet, grooved for twenty-eight ropes, about 1⅞ inches diameter. This half-wheel is a magnificent single casting with two sets of arms,—ten to a set,—and deeply-flanged rim, united by bolts at the periphery boss left for hoops to be shrunk on in place. This firm also has a smaller wheel, in halves, with hooped boss, and rim jointed by shrunk-on circular hoops sunk level with sides of rim, as shown in Fig. 12.

Carels, of Ghent, show a wheel with double arms, boss bolted with space left between to ensure grip of shaft, wheel

in halves, joints occurring midway between two arms, rim hooped and bolted, as in Fig. 13. Crepelle & Garaud, of Lille, show a 1200 H. P. engine, with a wheel in four or more parts, and dynamo on each side of wheel. It has a very heavy boss with light rim, cottered at joints, and square hoops shrunk on under rim.

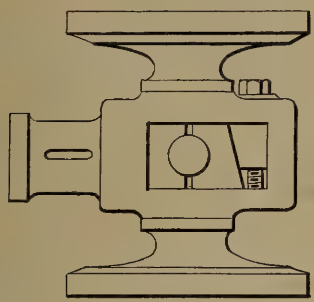


FIG 14

Garnier & Faure-Beaulieu show a wheel in halves, cottered rim-joint, boss bolted on one side, hooped on the other.

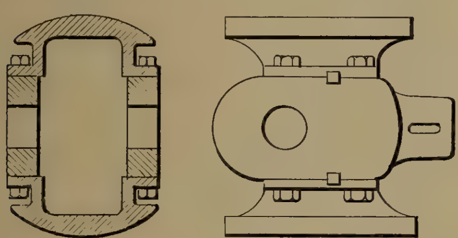


FIG. 16

A most interesting study of crossheads and connecting-rods is afforded to the wanderer at large in the exhibition. The essentials of a crosshead are few and well-defined. Given a bored-out trunk guide,—and this is the rule, with one or two exceptions, throughout the exhibition, — little variation in type would seem to be possible. The exact contrary is the case, however; and the ingenuity and lavish expenditure of labour used to avoid the plain, simple steel box-casting, with cast-iron slippers top and bottom, and bosses for the piston-rod and crosshead-pin, is as remarkable as it is inexplicable to a non-Continental observer. Fig. 14 shows a fair sample, of absolutely faultless workmanship, in the big engine by Carels, of Ghent. First of all, what we should call an admirable small end for a connecting-rod with wedge adjustment, is cottered to the piston-rod. To this are fitted, above and below, the slipper plates, of cast iron, having singularly little bearing upon the flats where they meet the crosshead, as compared with those of the box-block pattern. Necessarily a forked end is required to the connecting-rod (Fig. 15), and at a considerably enhanced cost in forging and tooling this is provided. The eyes are split for the purpose of gripping the perfectly plain steel pin by the steel set-screws.

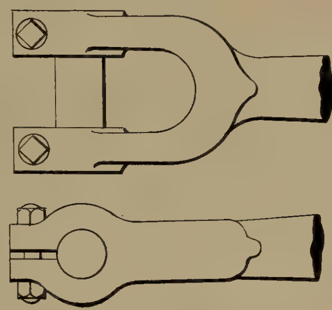


FIG. 15

In another large engine these details are exactly reversed, the split steel fork-end being in this case a part of the crosshead. Perhaps the simplest crosshead observable is that upon Dujardin's 2000 H. P. engine, which is practically a box crosshead of forged steel, the top and bottom being left open. The cast iron slippers are screwed to the thick edges of the sides, as in Fig. 16, a dowel or key being inserted to take the strain off the screws. The corresponding small end for the connecting-rod is shown in Fig. 17. Farcot's crosshead,

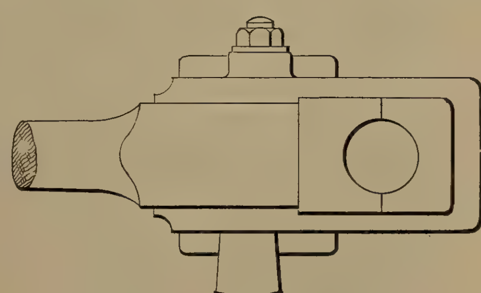
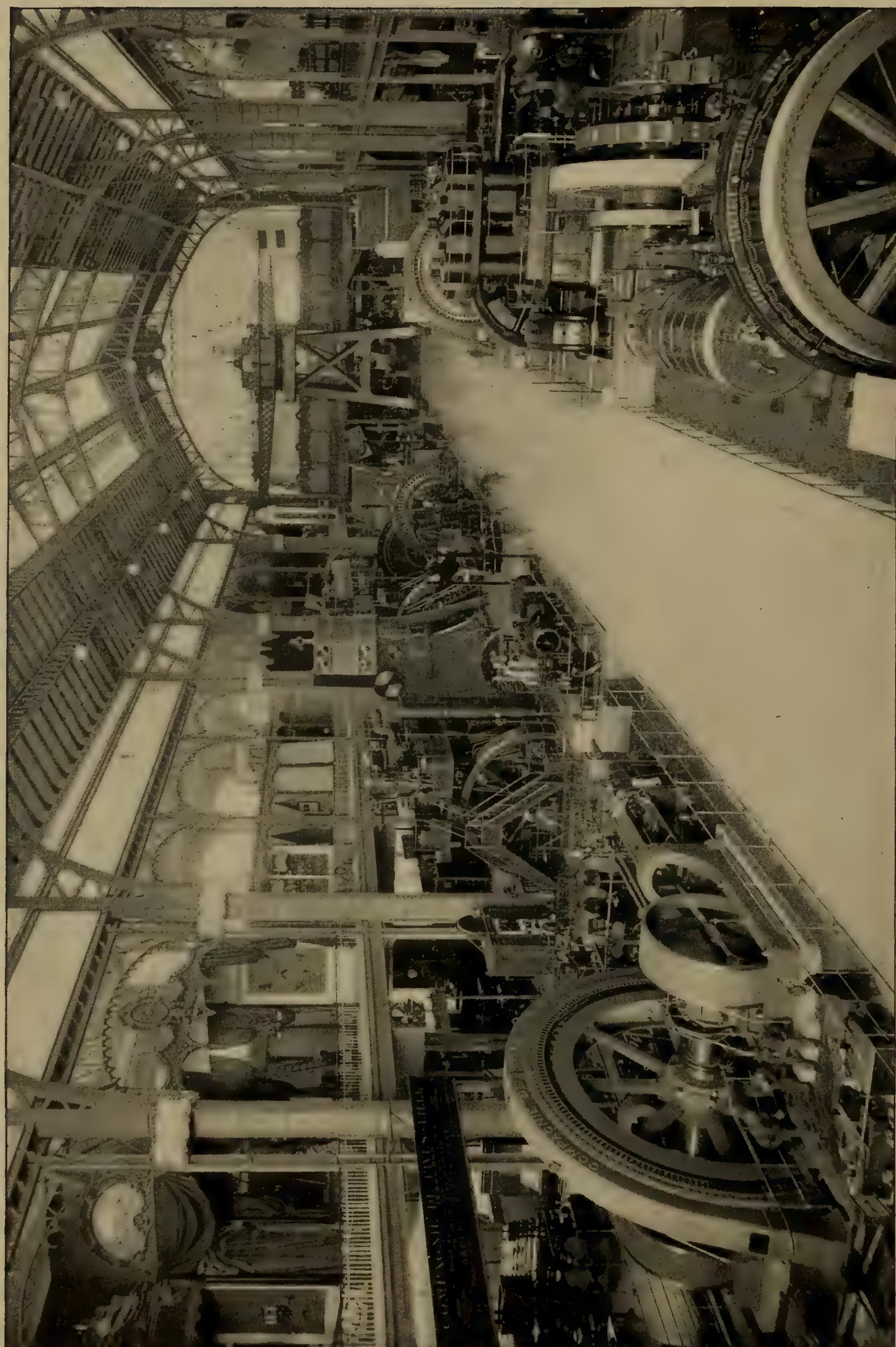


FIG. 17



THE FRENCH SECTION OF THE ELECTRICITY BUILDING AT THE PARIS EXHIBITION

of forged steel, Fig. 18, is provided with a cap and brasses, like an ordinary bearing, the pin being, of course, a fixture in the fork-end of the connecting-rod.

The unwisdom of providing screw or wedge adjustments for the crosshead slippers seems to be generally accepted, although the opportunity for getting in a little extra complication can hardly have been allowed to go by without a struggle. The convenience of a large nut on the piston-rod for the purpose of forcing off the crosshead when required, does not yet seem to have been adopted, though in some cases the same end is sought by the provision of a reversible gib, so that the cotter can be used to wedge the piston-rod out of the crosshead.

Most of the large engines in the exhibition have the assistance of an ad-

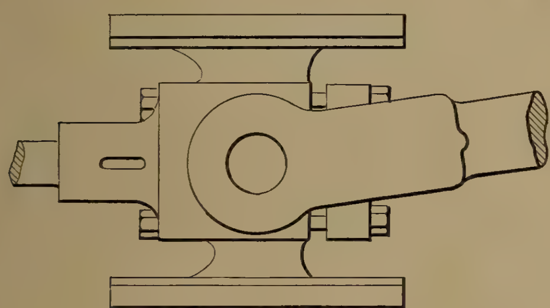


FIG. 18

justable pad or semi-bearing in carrying the weight of the piston and rod, and thus preventing the wear of glands and stuffing-boxes. A typical instance, by Carels, showing also the connection between the cylinders of his tandem engine, is shown by Fig. 19. Here a trough or half-bearing, provided with trunnions, is carried by a little double plummer-block, like an ordinary pivoted bearing for line shafts. Wear is taken up by inserting a liner between the foot of the block and the seat or facing upon the trunk casting. Dujardin and some others make their pads adjustable vertically by means of a screw and nut, as in Fig. 20; but this not only lacks the solidity of the pattern just described, but offers a fatal facility for over-adjustment, which is impossible where a liner has to be inserted to raise the pad. The half bush in which the piston-rod runs is usually lined with white metal.

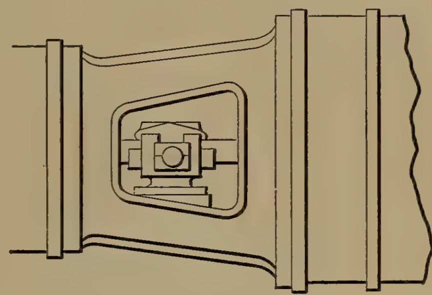


FIG. 19

The practice of fitting these pads at the crosshead end of the piston-rod,—*i. e.*, close to the front stuffing-box,—followed by several makers at the exhibition, seems to ignore the carrying

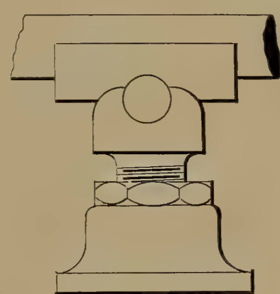


FIG. 20

power of the crosshead; and if the engine is running "outwards," any pressure of this kind, tending to lift the crosshead off the lower guide, would be

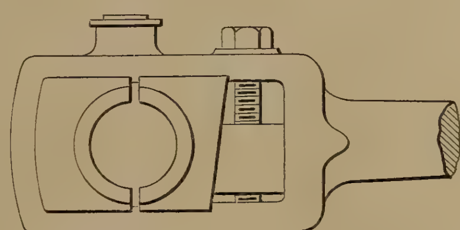


FIG. 21

likely to result in a "knock" at the inner end of the stroke. It cannot be said that all the Continental engines run with that freedom from knock and

vibration which we should expect from high-class engines.

In the large, or crank-pin, ends of the connecting-rods on view at the exhibition much variety is observable, though two types predominate largely, the solid end with wedge adjustment, shown in Figs. 21 and 22, and the marine pattern in several varieties, shown in Figs. 23 and 24. The big Fives-Lille engine has a very objectionable type of big end, Fig. 25, where the end of the rod is formed into an open jaw. The brasses are first put into place

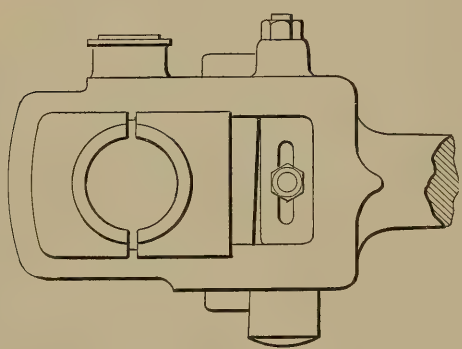


FIG. 22

and then a sort of square hoop is slipped over the jaws; the cotter is then dropped into the slot, and a loose plate, fitting endwise between the jaws, and slotted for the set-screw to move in, is placed against the cotter. No other security than this set-screw is in evidence against the general breakup which the loss of

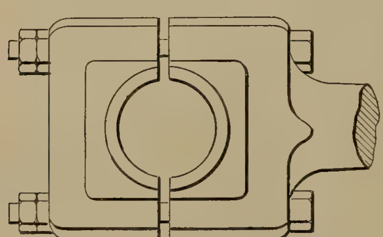


FIG. 23

the cotter would be pretty sure to entail. In many of the larger engines the large-end "brasses" are of cast iron, lined with Babbitt metal, a highly sensible plan where the dimensions are ample enough to admit of it.

And now we come to valve gears,— a subject calculated to appall the boldest investigator. The writer does not propose to illustrate any of these gears in detail for the simple reason that an intelligible description of almost any one

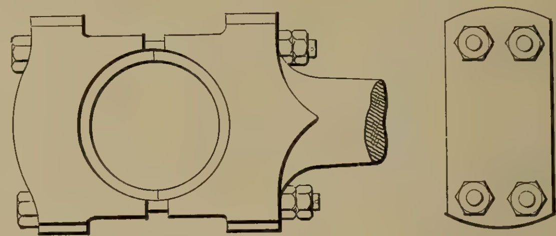


FIG. 24

of them would occupy at least a page and a half of this magazine, and there are scores of different systems to be dealt with. There are degrees in complexity, as in most other things, but Messrs. Weyher & Richemond, of Pautin, who exhibit several engines, may fairly claim to have reached the climax with their Lefer system of valve gear. Fig. 26, which is not to scale, but substantially accurate as to proportion, shows the structural peculiarities necessary in the engine to adapt it for receiv-

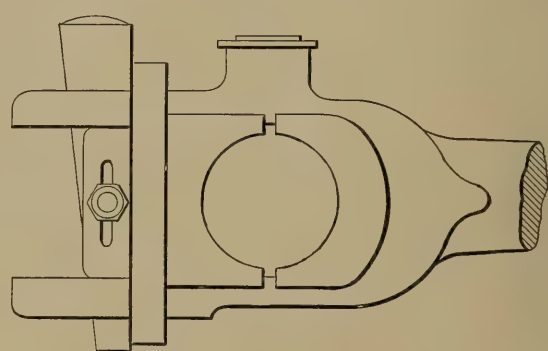


FIG. 25

ing this gear. It will be seen that the actual length of cylinder denoted by the indicator cocks is little more than one-half its apparent length, the end portions being appropriated to the valve-chests. At the back end the valve gear is entirely open to view, occupying perhaps a foot more of the total length,— the stroke of the engine is one metre,— while the gear at the front end is enclosed by a portentous cage or frame.

Then comes the trunk guide and then the bed proper, which is an exceedingly massive and well-designed casting of the Allis pattern. It will be noticed that the diameter of the trunk guide is greater than the crank length.

The valve gear itself, which derives its motion from bevel gear on the disc shaft, and operates, by a sort of twisting motion, valves working over parts in the cylinder covers, is a veritable labyrinth in motion, repeated at the other end of the cylinder, and controlled by an enormous drum governor on the disc shaft. If the piston ever requires withdrawal, for examination or repair, the cost of taking off and replacing the back cylinder cover is likely to amount to something considerable. The Lefer system is said by the makers to be more economical than the Corliss system. It may be so, but surely no saving less than 50 or 60 per cent. could justify such formidable preparations.

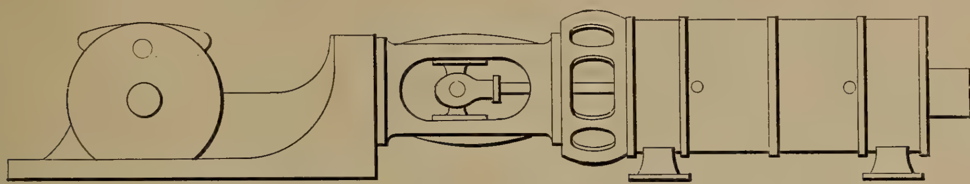


FIG. 26

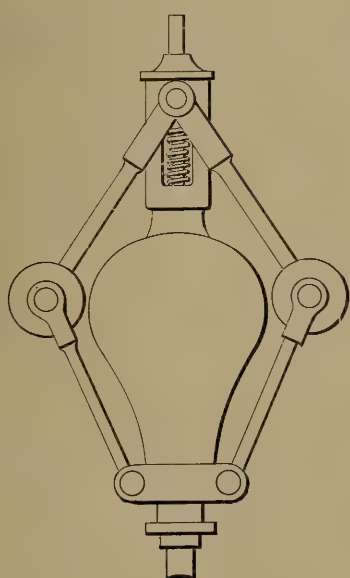


FIG. 27

The 1200 H. P. horizontal engine of the Fives-Lille Company is said to have a crew of six men to drive it; and when we consider the amount of mechanism to be lubricated, kept clean, and looked after generally, it does not really seem an excessive staff for the purpose. The object of highly intricate valve motions is presumably, after maintaining a full valve-opening as long as desired, to close as sharply as possible. This vain seeking after a sharply defined cut-off corner in the diagram is responsible for more waste of time and money than any other detail about the engine. If the money so spent were put into the crank-shaft, main bearings and fly-wheel, the user of the engine would, in the long run, be a gainer.

Not all the foreign engines are so laboriously equipped. As the mind, fatigued with the hum and roar of a crowded city, turns for relief to the contemplation of a country lane, so the jaded observer, amid the cams, and cranks, and detents, the guides and slides, the springs and tappets,—busy witnesses of the fertile ingenuity of our

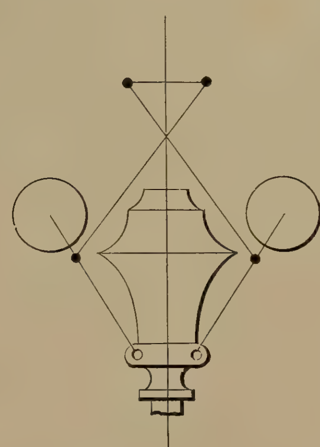


FIG. 28

Continental brethren,—finds now and then a spot where the not excessively difficult operations of admitting steam to a cylinder and cutting it off again are achieved without the usual brain-worrying racket. One of these oases in the

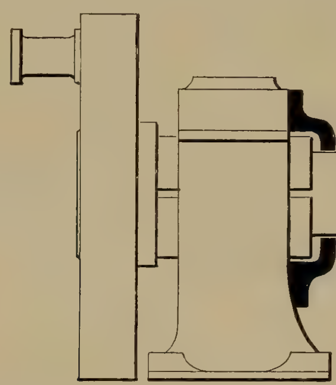


FIG. 29

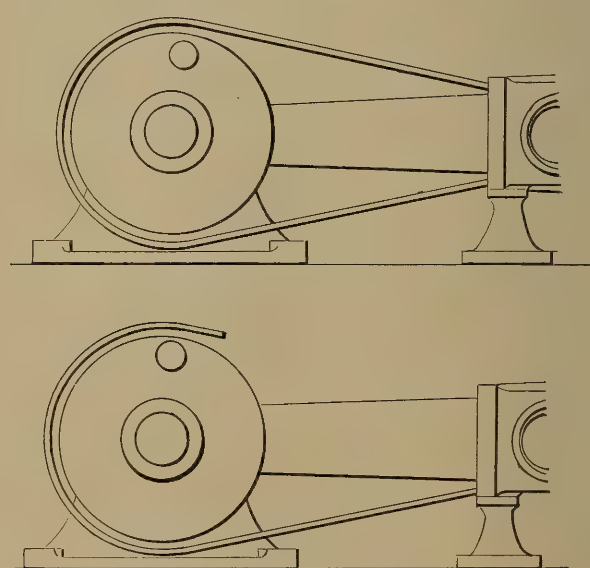
desert is the engine of Brietrix et Cie, of St. Etienne, who employ a peculiarly simple variation of the Collmann gear, noiseless and pleasant to look upon. Oil instead of air is used in the dashpots of this gear, with the best of results, apparently, though whether the descent of the valves is rapid enough can be determined only by the indicator cards. The Collmann gear enjoys deserved favour on the Continent.

The great single-cylinder engine,—1300 H. P., – of Farcot is an admirably finished example of massiveness and simplicity, though rather too lavishly nickel-plated and decked out with ornamental brass work. The plain Corliss gear with which this engine is fitted contrasts favourably with the Corliss-plus-some-one-else's "improvements" which most French makers employ. Large single-cylinder engines are rather a feature of French practice at the exhibition; but the heavy knock at each end of the stroke not infrequently met with, resulting from the use of high-pressure steam with a high degree of expansion, does not argue in their favour.

The 3000 H. P. triple, horizontal engine of the Augsburg-Nürnberg Company,—the largest engine in the exhibition,—is a model of simplicity and good work in the valve gear, and indeed, throughout. The simplest valve gear, however, in the collection is upon an English engine, the Richardson-Rowland trip-gear, used by Messrs. Robey & Co., Ltd., on their 550 H. P., horizontal compound. After all, the proof of the pudding is in the eating, and from the known results of the Collmann, Corliss, and Richardson gears there can be little real advantage from added complexity.

The majority of German, Austrian, Swiss, and Belgian engines in the exhibition are fitted with double-beat or equilibrium drop valves, sometimes of cast iron, whose fall, accelerated by a coiled spring above the dashpot piston, is prevented from injuring the valve seats by an air cushion. Some of these fall noisily, and, it cannot be doubted, destructively; others come down on their seats gently enough.

An important innovation is exhibited by Van der Kerchove, of Ghent, who



FIGS. 30 AND 31

suppresses the valve seats altogether, and fits instead perforated or ported cylindrical liners, within which rise and fall ordinary piston-valves. This type of valve is quite silent in its fall, and cuts off the steam with rapidity and certainty. The movement of the valves is about twice that required for drop valves of the double-beat pattern. The gear is a modified Collmann. The engine

exhibited is the first which the firm has turned out with this valve arrangement, and it should have a future before it. The firm of Piguet & Co. show the only slide-valve engine of any size in the exhibition. It has a 34¼-inch cylinder,

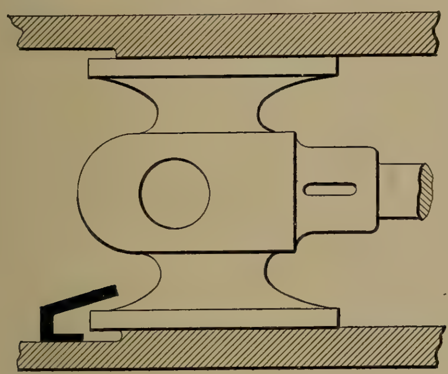


FIG. 32

with 43¼-inch stroke, and runs at 75 revolutions per minute.

Of governors at the Paris Exhibition an extended treatise might easily be written. All possible, and some impossible, types are to be seen. Many engines, and some of them by eminent makers, are fitted with the slowly-revolving, heavy-balled Watt governor. The Porter governor is also largely in evidence, both in its original condition and with every conceivable modification. One example, by Weyher & Richemond, is combined with a spring, as shown in Fig. 27, and in addition has a differential motion, worked by a small pitch chain. Some loaded governors with crossed arms have also crossed suspension links. The governor shown diagramatically in Fig. 28 is also to be met with.

Many of the trip-gear engines have a drum governor on the line shaft, modifying the throw or the position of the eccentrics; but some of these seeming governors upon line shafts are merely fly-wheels for the purpose of reducing the shock upon the teeth of the driving gear,—an idea well worthy of careful investigation. The huge Borsig vertical engine has a drum governor on its inclined line shaft, and so has the large vertical engine of the Augsburg-Nürnberg Company. To chronicle all the eccentricities in governors which are to be seen would only weary the reader. Outside the British section spring-loaded governors are conspicuous by their absence; and many most ingenious devices for doing what might be better done by a spiral spring will repay the curious investigator.

Another very usual attachment on British engines,—the sight-feed displacement lubricator for cylinders,—is not to be found upon any of the Continental engines, its place being taken by a small plunger pump, usually driven by a tiny crank-pin screwed into the end of the line shaft, and feeding into the valve chambers. Oil from an ordinary drop-feed glass lubricator vessel drips at the desired rate into the suction valve of the little pump, and is forced into the steam space without trouble or adjustment. The same kind of pump is also used for oiling the main bearings.

A small lip or flange round the main brasses (Fig. 29) is a very common adjunct, and is well worth its cost, in keeping the oil which runs down from the bearing from disfiguring the face of the bed. The arrangements for catch-

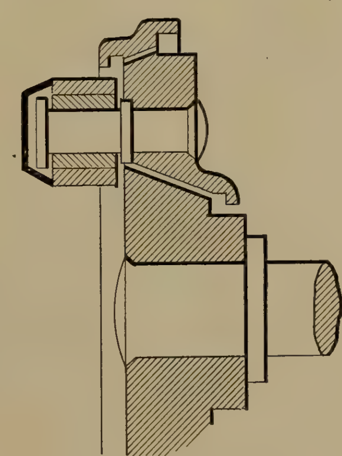
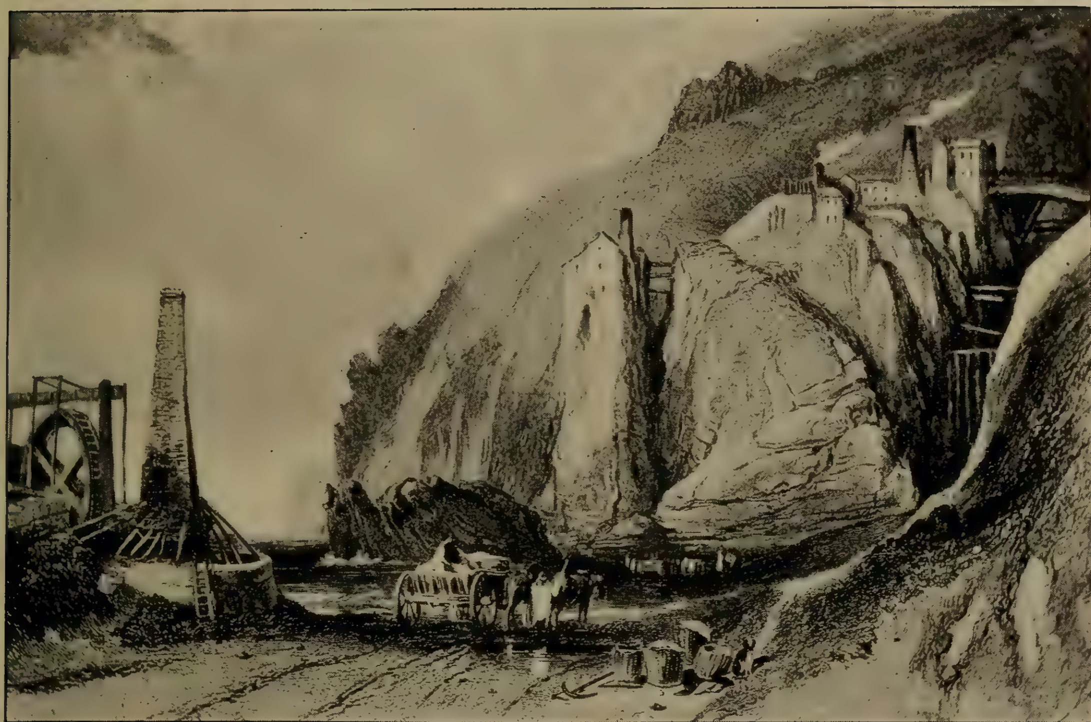


FIG. 33

ing the oil thrown off by the crank-pin are usually rather elaborate. Two forms are shown in Figs. 30 and 31. They are always made of blued sheet-steel or Russian iron. An ingenious little shoe (Fig. 32) is often used to keep the crosshead from throwing oil out at the end of the trunk.

Weyher & Richemond adopt a rather ingenious form of crank disc by which all necessity for oil splashes is eliminated. The disc is of cast steel (Fig. 33), having an annular groove on the side next the bed, of a diameter somewhat less than the crank-pin circle. Oil is fed into this groove and passes to the crank pin by a diagonal hole. Owing to an oil-tight cap attached to the connecting-rod brasses the surplus oil is compelled to pass out between the latter and the face of the disc, whence it collects in the larger annular groove. Again, it passes through holes in the disc to the third annular groove at the back where it is met by a scraper and conducted to its source. It is continuously circulated in this way by a small pump. Whether this arrangement is cheaper or more effective than the ordinary centrifugal crank-pin oiler with a sheet-steel guard round the disc and an oil tray below, must be left to the reader to decide. Much that is valuable and interesting will have to go unchronicled in this brief survey. The eye is caught at every turn by some little device or improvement which our ever watchful competitors are applying to their engines. Many of them, as the reader will have already discovered for himself, are well worth having,—some are very decidedly the opposite. At all events, the British steam-engine maker will do well to note the necessity for greater attention to detail and finish if he desires to do business on the Continent on equal terms with his foreign competitors.

It is the firm conviction of the writer that British-made steam-engines, in their essential parts, are at least the equals of any in the world. Add but the Continental finish and attention to small details to the British characteristics of simplicity and solidity, and Great Britain will always hold her own.



BOTALLACK MINE, CORNWALL, NEAR TREVITHICK'S BIRTHPLACE

RICHARD TREVITHICK

THE PIONEER OF HIGH-PRESSURE STEAM. 1771–1833

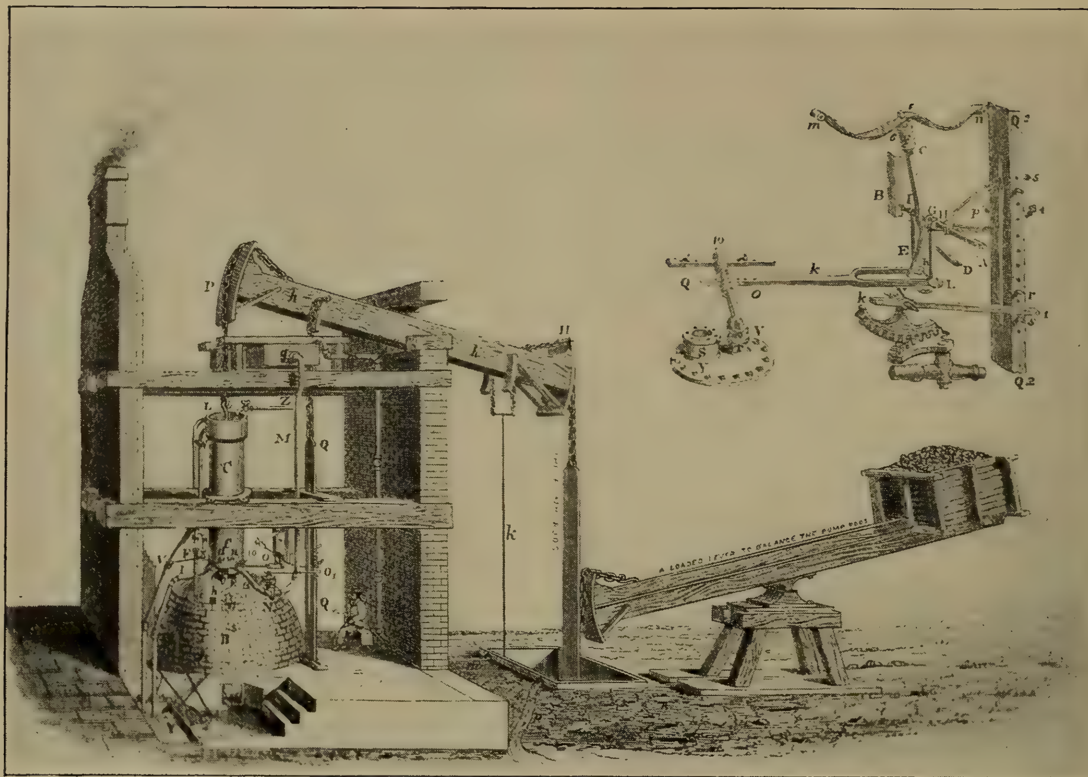
By Arthur Titley, M. Inst. M. E.

THE engineer is nothing if not progressive; and from this very circumstance the fact arises that he has rarely time or inclination to study the history of mechanical matters, or of those men who have laid the foundations of that knowledge and experience upon which he himself, consciously or unconsciously, builds.

It is extremely difficult at the present day to unravel the inextricable tangle of events which go to make up the early history of the steam-engine; and no work has yet been published which puts, with any degree of fairness or accuracy, the names of the many men whose labours have assisted in making that history in the place which each deserves.

The names of Watt and Stephenson convey to the average mind all that it desires to know relative to the history of the steam-engine; but it is to few indeed that the names of such men as Newcomen, Smeaton, Hornblower, Murdoch, or Trevithick appeal with any degree of appreciation of their labours or of our indebtedness to them to-day. It may, therefore, not be out of place to add to the list of historical articles which have appeared in the pages of CASSIER'S MAGAZINE some incidents in engineering history long passed by, and in the career of a man whose life's work has had an enormous, though almost forgotten, influence upon everyday practice.

From the year 1710, when Newcomen built his first pumping engine, the development of the use of steam as a source of motive power had steadily



A NEWCOMEN ATMOSPHERIC ENGINE OF TREVITHICK'S TIME

proceeded. When Richard Trevithick appeared in the field, Boulton and Watt's engines, with waggon boilers, using steam at a pressure of from about two to three pounds per square inch above that of the atmosphere, and feeding water into the boilers by gravitation, represented the most advanced practice of the day. These engines took steam through the greater part of the stroke, and though Watt appreciated the advantages of expansion, he was, through life, a determined opponent of the use of high pressures.

But Boulton and Watt were not the only engine builders of that day. In Cornwall, England, the county of Trevithick's birth, and the locality in which steam was at first most used, many atmospheric engines were built at the mines, castings being obtained at some local foundry, and forging and fitting being done in the blacksmith's shop attached to the mine, each engine bearing evidence of the individuality of its designer, and there arose a class of men as Cornish engineers, strong in their own resources, and greatly opposed to interference from the outside world.

Born and bred among the Cornish mines, and gifted with mechanical abilities and instincts amounting to genius, at a time when Watt was in daily rivalry with Cornish engineers, it would, indeed, have been strange if Richard Trevithick had not played an important part in the growth of the usefulness of steam. The leading part he did take in this development may be best expressed in the words of his life-long friend, Davies Gilbert, a man of great scientific attainments in his day and a president of the Royal Society. Gilbert wrote:—

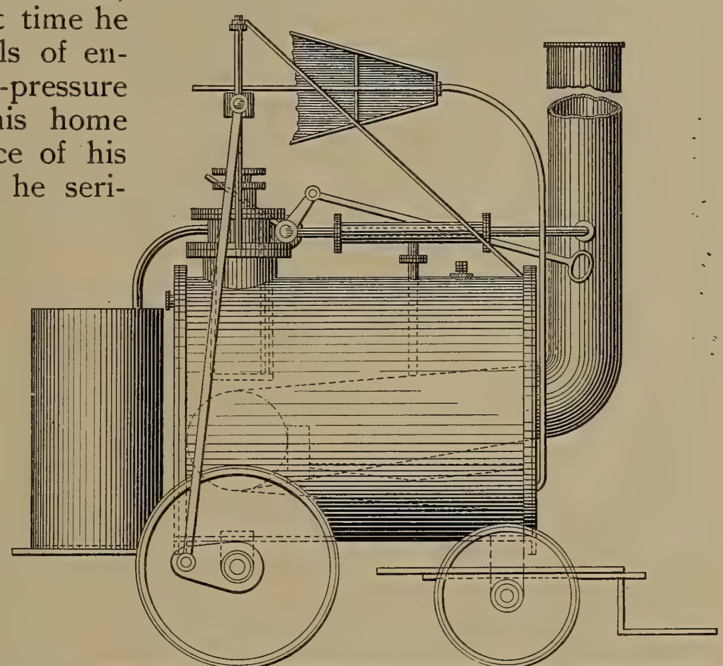
"On one occasion Trevithick came to me and inquired with great eagerness as to what I apprehended would be the loss of power in working an engine by the force of steam raised to the pressure of several atmospheres, but, instead of condensing it, to let it escape? I, of course, answered at once that the loss of power would be one atmosphere, diminished power by the saving of an air-pump with its friction, and, in many cases, with the raising of condensing water. I never saw a man so delighted, and I believe that within a month sev-

eral puffers were in actual work." Trevithick was a man of splendid physique, six feet two inches in height, and of a sanguine and genial temperament, with all the incompatible characteristics which are so often found to be blended in the man of genius. Hopeful, and with indomitable energy, he rarely failed to bring his ideas to a mechanical success; while his want of caution as regards money matters, and his impatience in dealing with men whose brains moved at a slower rate than did his own, as rarely failed to ruin them commercially. On the other hand, the personal charm of the man must have been great, as evinced by his letters and from the recollections of those who knew him, while we read of workmen who threw up their jobs to work for "Captain Dick."

It was in 1796 that Trevithick sought the advice of his friend, Davies Gilbert, as mentioned above. At that time he had constructed several models of engines to be worked by high-pressure steam which were tried at his home in Camborne in the presence of his friends. From that time on he seriously devoted himself to the construction of engines and boilers capable of being used with increased steam pressures, and by the year 1800 he seems to have built many. Some of these were condensing, and some exhausted their steam into the air; some were self-contained, and some had their boilers set in brickwork. They frequently had their cylinders let into the boilers, and had slide bars and connecting rods. A few years later one is mentioned as having two cylinders with cranks at right angles, and one at least exhausted its steam into the chimney. In 1800 he erected a condensing beam engine for winding at Cook's Kitchen mine, which was still at work in 1869. It had a wrought iron boiler giving steam at a pressure of twenty-five pounds per square inch, a timber beam, a parallel motion, and a crank. Steam was distributed by means of a four-way cock, worked by a plug rod and gear handles, and a plunger pump, similar to those now in use, fed water into the boiler.

In 1802 Trevithick and his friend, Andrew Vivian, took out a patent embodying the former's improvements in high-pressure engines and boilers which covered many points then new. Among them may be mentioned globular and cylindrical boilers with external and internal fireplaces, engines with two cranks at right angles, a feed-water heater, feed pumps, and a road locomotive. Without further describing the objects of this patent, it may be said that the specification is full of interest and marks an epoch in the history of the steam-engine, and in its far-reaching consequences is more important than that of Watt.

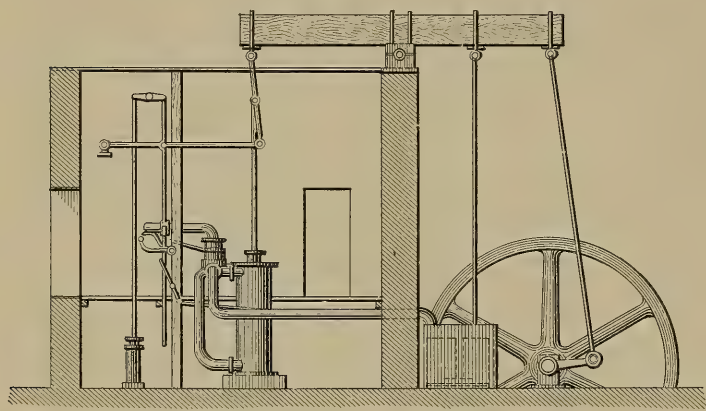
Among the models mentioned as having been made by Trevithick about the year 1796 was a locomotive. It is in the South Kensington patent museum, and is one of the few existing records of Trevithick's work. Prior to this the only attempt at steam locomotion carried out on a practical scale was that of Nicholas Joseph Cugnot, in Paris, in 1769 and 1770. Cugnot built two road locomotives, one of which still exists,



THE CAMBORNE ROAD LOCOMOTIVE, 1800

and is said to be an excellent piece of work.

In the year 1800 Trevithick and Davies Gilbert had satisfied themselves as to the fact that sufficient adhesion could be obtained by smooth wheels for traction on common roads. They hired the only chaise then to be had in Camborne, and, having taken out the horse, worked the chaise up a steep hill by turning round the spokes of the wheels with their hands. Trevithick never had any more doubt but that smooth wheels were sufficient to propel a vehicle. Years after, when his experiments were known to the world, inventors flocked into the field, but could not profit by what had been done before, or appreciate the simplicity and directness of Trevithick's methods. Immediately after this Trevithick was building his first steam carriage. As manager of various mines, he had his own workmen engaged in erecting and repairing machinery, and when they could be spared he employed them upon his locomotive.

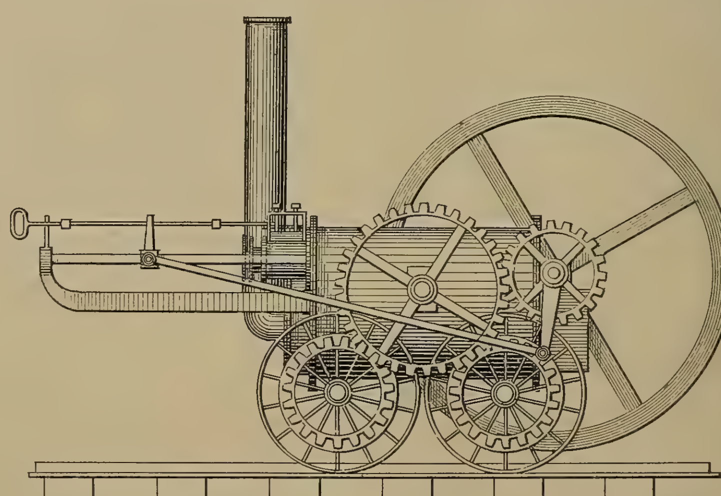


WINDING ENGINE AT COOK'S KITCHEN MINE, 1800

The engine was on four wheels, and had a boiler with a cast iron shell and a wrought iron fireplace and return flue. The cylinder was vertical and let into the boiler. It seems to have had a feed-water heater, and to have exhausted its steam up the chimney; a leather bellows, worked off the engine motion, was also provided to increase the draught if necessary. The credit of the invention of the blast pipe has been taken from Trevithick by many writers on account of the experimental use of the bellows.

It was on Christmas Eve, 1801, that the first trial was made. The engine started from Tyack's smith shop, and carried a load of passengers up a grade of 1 in 15 or 20. An eye-witness said:— "When we seed Cap'n Dick was a-going to turn on steam, we jumped up, as many as could, may-be seven or eight of us. 'Twas a stiffish hill going from the Weith up to Camborne Beacon, but she went off like a little bird."

The engine was again tried on December 28, 1801. After running for a time successfully, something got out of order, and, as evening was coming on, it was run under a shed and the company adjourned to an inn to cheer themselves with roast goose and seasonable drinks. How long they stayed history does not relate, but on returning to the engine they found that everything combustible, including the shed, was burned.

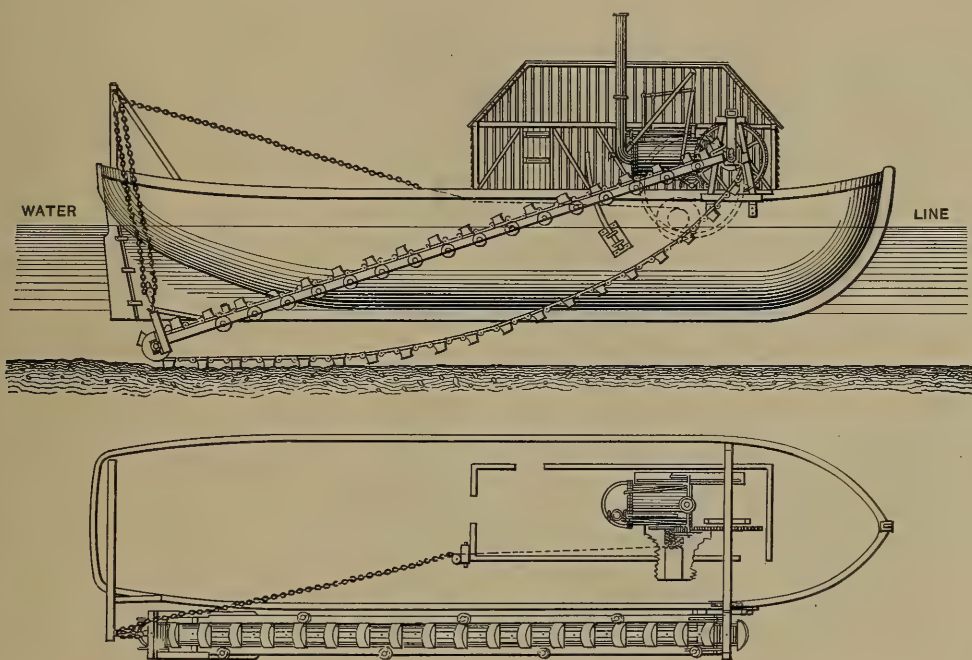


TREVITHICK'S LOCOMOTIVE AT PEN-Y-DARRAN, SOUTH WALES, 1804

Trevithick soon built another road locomotive which had a carriage body fixed upon it, and was successfully run

in London. It had a boiler entirely of wrought iron, with internal fireplace and return flue. The cylinder was horizontal, and steam was exhausted up the chimney, the bellows having disappeared.

In 1803 he built a locomotive to run on an existing line of cast iron tram plates at Pen-y-Darran, in South Wales. This engine was the subject of a bet between a man named Hill and Samuel Homfray (for whom the engine had been built) that it would not perform the journey of nine miles with a load of ten tons; but seventy men were carried



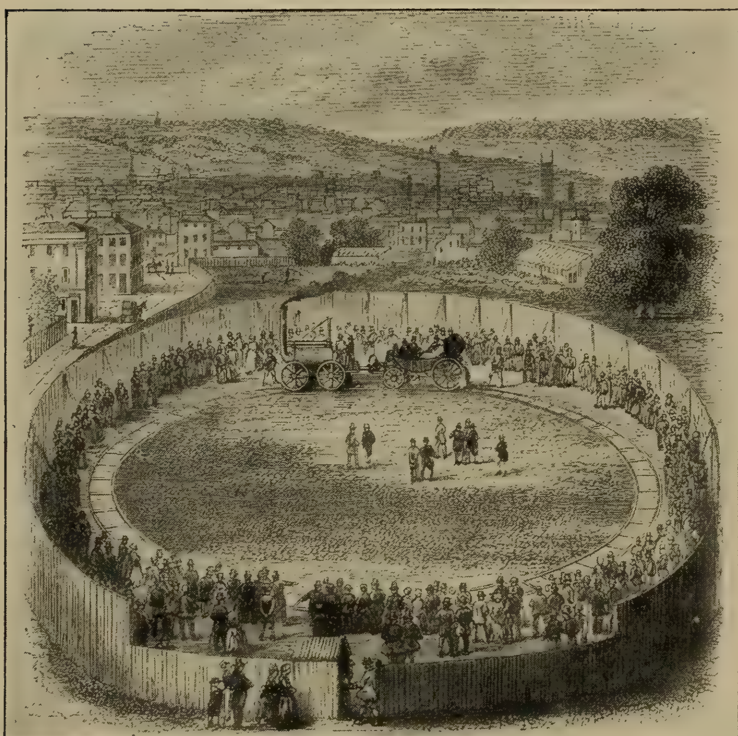
TREVITHICK'S DREDGING MACHINE, 1803

the whole of the way, as well as the allotted load.

In 1805 Trevithick sent a locomotive to Newcastle for Mr. Blackett, of Wylam Colliery, which had flanged wheels to run on rails. It was never used for the purpose intended, but was put to drive a cupola blast in Newcastle. William Hedley was manager for Blackett at the time, and five years later patented a similar engine, claiming to be the original user of smooth wheels for steam traction. Timothy Hackworth also worked for Blackett, and George Stephenson was close by, and his first engine was built at Killingworth in 1814. Trevithick built another locomotive in 1808 which he ran upon a circular railway in London, near the site of Euston railway station. This engine was exhibited for three or four months, and carried passengers at a speed of twelve miles an hour. He was thus the first to build a locomotive on a practical scale to run on rails, and the first to make one with flanged wheels. He was also the first to exhaust the steam up the chimney, and never attempted to get over the imaginary difficulty of insufficient wheel-grip which puzzled so many of those who followed him.

The use of Trevithick's high-pressure engines now spread rapidly. At one time we read of his travelling about the country supervising the construction of engines in upwards of thirty different foundries. Most of these engines differed from one another in details, and were applied to purposes of which many were then new to steam,—winding, grinding corn, rolling and puddling iron, working hammers, boring cannon, pumping, threshing, rock-breaking, in fact, supplying the want of small and cheap engines where the more costly Watt engine could not be used, as well as competing directly with the latter.

But it is not in the construction of high-pressure steam-engines alone that Trevithick helped to forward the enormous development of the use of steam which may be said to date from his early inventions. Whenever he could see an opening for its use, he was ready to design and build machines to assist that development. The bucket dredger is his, though it has been coupled with the name of Rennie, who used Trevithick's idea. Of these he built several, one of which belonged to the Trinity Board, and was employed to deepen the men-of-war's mooring ground at Woolwich.

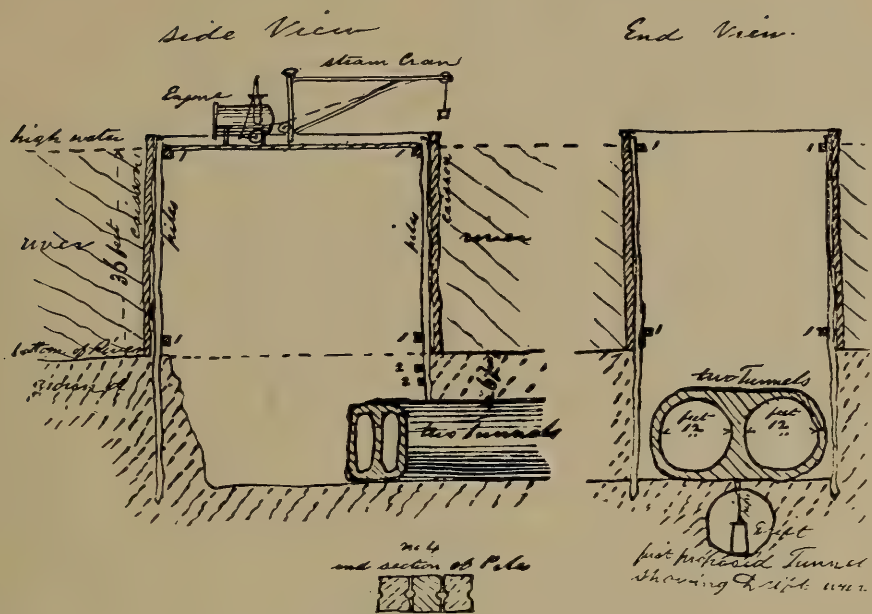


CIRCULAR RAILWAY AT LONDON, IN 1808

He designed and made rock drills, quartz crushers, paddle and screw propellers, threshing machines, steam ploughs and cultivators. He patented and made iron tanks for carrying liquids, etc., on board ship, and for water ballast, and attempted to introduce these tanks into the Navy for carrying drinking water. To tell of his pioneer attempt to tunnel under the Thames, in which he was so nearly successful, would take up more space than a magazine article would permit. It must, therefore, suffice to say that he constructed a driftway from Rotherhithe through the treacherous water-bearing strata of the river bed to within 70 feet of low-tide level on the north side, and would probably have had the reputation of being the first engineer to carry out a work of this kind in London but for the dissensions which arose in the management in the company for which he was working.

Any account of the career of Trevithick would be incomplete without reference to his romantic life and adventures in South America, because he was the first to introduce the steam-engine into that part of the world, and because nothing in his history better exemplifies the character of the man.

A Swiss speculator named Francisco Uville had, with others, become interested in a scheme for draining the ancient and deserted silver mines of Peru. He was deputed by his partners in the venture to visit England to obtain engines and pumps for the purpose. Uville accordingly did so in 1811, and was referred to Boulton & Watt. He was told that engines could not be built small enough to transport over the mountain paths of the Cordilleras, 15,000 feet above the sea level, and that, even if this were so, the condensing engine would work but ill in the attenuated atmosphere at the elevation of the mines. He returned to London unsatisfied, but, while there, happened to see a model of a steam-engine and inquired what it was. He was told that it was the high-pressure engine of Richard Trevithick, and he at once bought it, and took it back with him to Peru. Having proved the capabilities of the model, he returned to England. On landing at Falmouth he was introduced to Trevithick, who at once undertook to build engines to suit his purpose, and which could be made in small enough pieces to be carried on

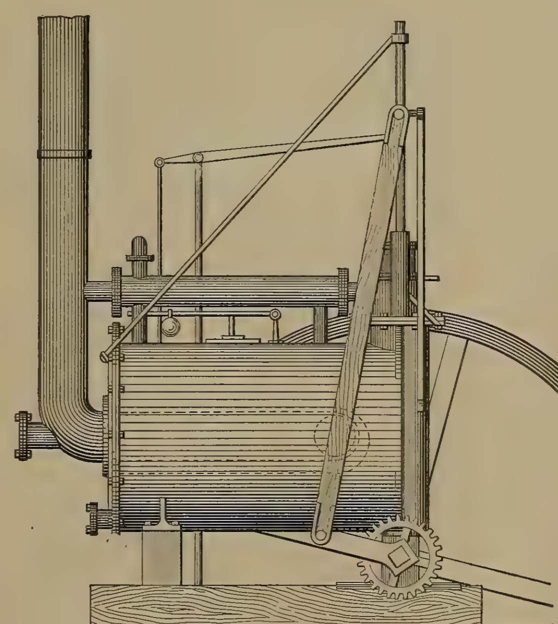


PROPOSED TUNNEL UNDER THE THAMES. FROM A SKETCH IN ONE OF TREVITHICK'S LETTERS

the backs of mules across the mountains. Uville stayed for some months at Trevithick's house in Cornwall, and was taught much relating to mining and mining machinery. A fortnight after their meeting Trevithick had arranged to build for him six engines, besides pit work and other machinery. Then came the usual hitch; money was not so plentiful as the foreigner had made out, and eventually Trevithick was made a partner in the venture, selling part of his shares to pay for the machinery ordered.

At last, in 1814, four steam pumping engines, complete with pit work, four winding engines, a portable engine on wheels, a crushing mill, a rolling mill, besides miners' and mechanics' tools, were shipped on board a South Sea whaler sailing from London, Uville and three Cornishmen going with them. On their arrival at Lima they were received with public rejoicings, and by a salute from the government batteries. The portable engine was soon at work in the mint at Lima, and the other engines were got up the Andes, and one pumping engine was put to work at the mines. The Spaniards were fully convinced that an era of great prosperity was at hand, and in flowing language drew a most hopeful picture from their imagination. Two magistrates who visited the mines to report upon what was being done there, drew up a document which concluded as folows:—

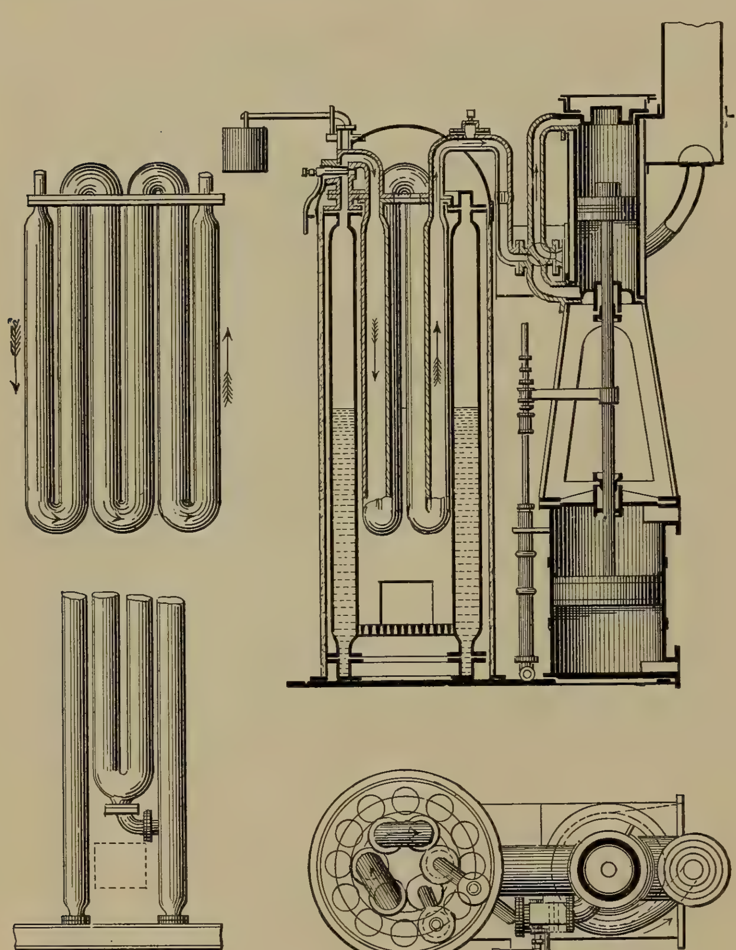
"But for the present we will congratulate ourselves that our labours, co-operation, and fidelity, keeping pace with perfect harmony with the exertions of the agents, the company may thus attain the full completion of their utmost wishes, extracting from the bowels of these prolific mountains, not the riches



DREDGER ENGINE AND LOCOMOTIVE OF 1808

of Amilcar's inexhaustible wells, not the treasures of the boasted Potosi in its happiest days, but a torrent of silver, which will fill all surrounding nations with admiration, will give energy to commerce, prosperity to this viceroyalty and the peninsula, and fill the royal treasury of our beloved sovereign."

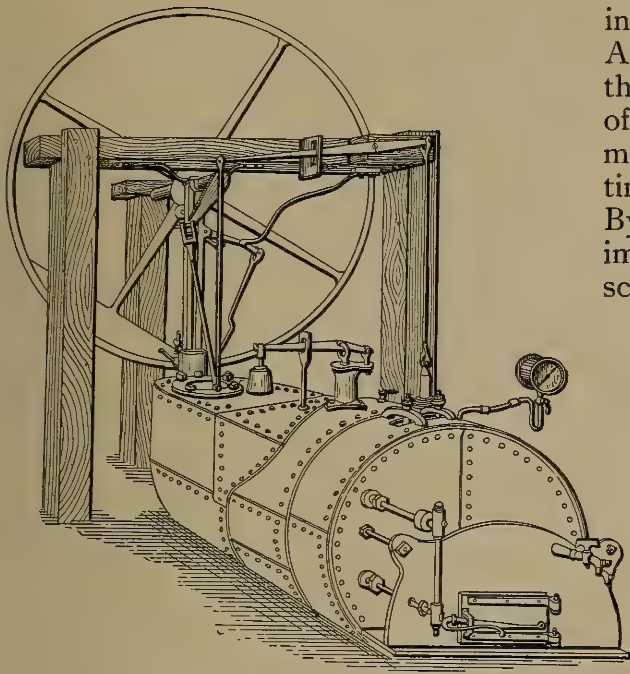
In 1816 Trevithick himself sailed for Peru, and the *Lima Gazette*, of February 12, 1817, after describing the operations at the mines, thus mentions his arrival:—" But what is of greater importance is the arrival of Don Ricardo Trevithick, an eminent professor of mechanics, the same who directed in England the execution of the machinery now existing in Pasco. This professor can, with the assistance of the workmen who accompany him, construct as many engines as are necessary in Peru without any need of sending to England for any part of these vast machines. The excellent character of Don. R. Trevithick, and his ardent desire for promoting the interests of Peru, recommend him in the highest degree to public estimation, and make us hope that his arrival in this kingdom will form the epoch of its prosperity, with the enjoyment of the riches enclosed in it, which could not be enjoyed without this class of assistance, or if the British Government had not permitted the exportation from England, which appeared doubtful to all those who knew how jealous that nation is in the exclusive possession of all superior inventions in arts or industry."



TREVITHICK'S SUPERHEATER

Trevithick found the mint at Lima (which was the property of the company) at work, and also two engines pumping water at the mine and two drawing ore; but found the Spaniards as much at a loss in their mining as they were in their engineering, and, if he had not arrived, the whole scheme would have fallen through. After taking the actual management of the mines for some time, however, he found much opposition from the original promoters of the company, who were not overpleased at his arrival. He eventually refused an offer of $8000 a year to continue as manager, saying that " on no account would he consent to contend with the jealousies and ill-treatment of the persons with whom he had to deal."

He now entered into many schemes, among others making grinding mills and furnaces with a view of substituting smelting for the amalgamation of silver ores, in which he was a considerable loser. He was granted a special passport by the Viceroy for the purpose of travelling through the country to inspect the general mining system and to intro-

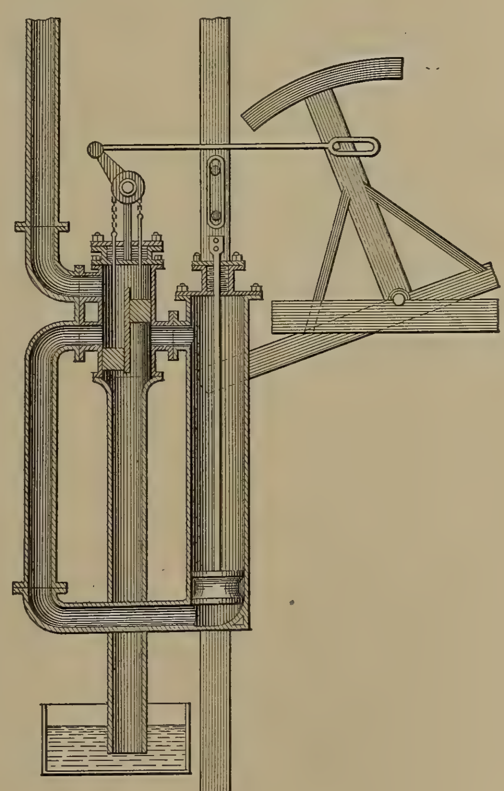


THE HIGH-PRESSURE ENGINE OF 1811

duce British methods of working. As a return for this the government granted him the right of taking possession of any new mining localities which he might discover. He also visited Chili and set to work mines which are still going, and it has been said that the name of Trevithick was better known in the neighbourhood of Valparaiso than in his native county of Cornwall.

He had commenced to work a copper mine upon his own account when the war of independence broke out, which cost Spain so many of her colonies. Trevithick invented a carbine made of brass, and was impressed by the revolutionary party, together with $20,000 of his money and property, to prove its use. But he was not a fighting man, and was soon allowed to return to his mine. Shortly after, the rival armies swept over his district, and he was driven from his property, leaving machinery and tools behind, besides £5000 worth of copper ore which was awaiting shipment. For some time he was on terms of intimacy with Bolivar, the South American patriotic leader and president of the Peruvian Republic, and lived at his house. During this time he saved the life of Lord Dundonald, who held a commission in the Chilian Navy, warning him of a plot to assassinate him. About this time, too, he raised from the wreck of a sunken frigate a number of brass guns for the Peruvian Government, taking as payment a quantity of tin and copper ore which was on board. By this he realised £2500, which he immediately lost in a pearl fishery scheme near Panama.

In 1821 or 1822 Trevithick left Peru for Bogota on a special mission for Bolivar. On his way, putting in at Guayaquil, he heard of rich mines in Costa Rica, and having had enough of Peru and South American politics, he threw up his engagements with Bolivar and went to Central America. Landing in the Bay of Nicoya, he met a Scotchman named Gerard, and the two proceeded inland to the mines of which they both had heard. These mines had recently been opened for the first time since the conquest of the country by the Spanish, under Pizarro. Trevithick and his companion stopped here several years, finally obtaining valuable mineral



DOUBLE-ACTING WATER-PRESSURE ENGINE AT WHEAL-DRUID MINE

and water rights, when they proposed to go to England to form a company to work them. But there was one drawback,—the difficulty of getting the ore to the coast. To get over this obstacle they started eastwards to discover a new route to the Atlantic, accompanied by some workmen and two Spanish youths who were going to Europe for their education. For three weeks they pushed their way over mountain and swamp, crossing torrents, and cutting their way through tropical forests. Their food consisted largely of monkeys and fruit, and at one time they stood in immediate danger of starvation, and one man died on the journey. After building a raft and a boat and travelling down the river Serapique, they arrived at Greytown in a woeful condition, the little clothing left after their passage through the forest hanging in rags upon them. From Greytown they appear to have gone to Cartagèna, where Trevithick met with further adventures. While out in a boat near the mouth of the Magdalena River he was capsized by a negro, who owed him a grudge. An Englishman, who held a commission in the Venezuelan Army, happened to be on the river bank shooting wild pig. Hearing cries for help, he arrived upon the scene just in time to shoot an alligator which was about to appropriate the inventor of the locomotive, whom he lassoed and pulled out of the water nearly dead, as he himself said, "Half drowned, half hanged, and the rest devoured by alligators."

Of his meeting with Robert Stephenson and his journey home, there is not space to write; but it will suffice to say that Trevithick eventually arrived in England, after eleven years of wandering, his sole possessions being the clothes he stood in, a gold watch, a drawing compass, a magnetic compass, and a pair of silver spurs. But he was received in Cornwall with the ringing of church bells and universal joy and soon forgot his privations, with his usual elasticity, for within a month of his return he was counting on getting a share of the £500,000 which his improvements in pumping engines are said to have saved the county. Trevithick and Gerard then endeavoured to form a company to work their Costa Rican mines, but with no success. At a meeting in London Trevithick was offered £8000 for his South American copper mines, but disagreed with the proposers and declined the offer. In the end he got nothing for either his South American or his Costa Rican mines.

Of all the labours of Trevithick's busy life it is on account of those bearing upon the improvement of steam-engine economy that posterity owes to him a debt which has never been either acknowledged or appreciated. In the early days of steam, the mine pumping engine naturally took the place of the standard in this respect. But Watt had raised the steam-engine to a certain state of comparative excellence, stopping short at a point from which its usefulness was to extend far beyond what it was capable of at that time. Trevithick, taking up the work at this point, raised the steam pressure used in pumping engines, by leaps and bounds, from Watt's 2 or 3 pounds above the atmosphere to 6 pounds in a globular wrought iron boiler, and to 50, 100, and 150 pounds per square inch in his wrought iron egg-ended and Cornish boilers, in the construction of which he overcame such great difficulties. So imperfect was the boilermakers' art at that day that the plates having been bent to shape by means of the hammer, and the rivet holes having been punched and drifted into something like alignment, it was customary to lay in the joint a piece of rope yarn before riveting up to ensure steam tightness. Under such conditions engineers will appreciate what it meant to build boilers for the first time which successfully worked for many years at the above-mentioned pressures, and in general design Trevithick's boilers of 1811 are nearly identical with many built at the present day.

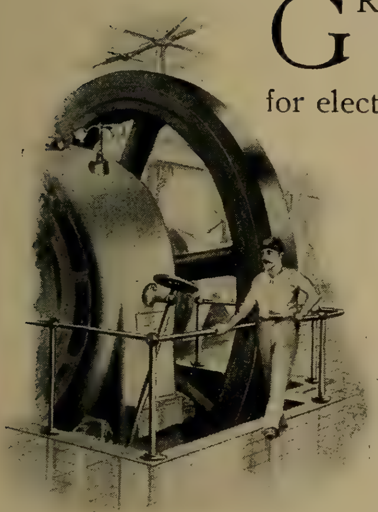
Of the inventive faculties, the daring and original experiments, and the earnest endeavours of the man to advance the practical use and improvement of the steam-engine, the writer has tried to give some idea. As the first and

consistent advocate of higher steam pressures, and with his experiments carried out on a commercial scale with steam pressures up to 150 pounds per square inch in everyday work, he indicated the line of advance that is being followed to-day; and most of his inventions which are at present in use are those which were developed with that view. Take away the Cornish and Lancashire boiler, the internal furnace, the non-condensing steam-engine, the portable engine, the feed-water heater and boiler feed-pump, the locomotive and the blast pipe, and we can form some idea of what Richard Trevithick did for engineering and for civilisation.

Those interested in the subject of early engineering history will find "The Life of Richard Trevithick," written by Francis Trevithick, and published in 1870 by Messrs. E. & F. N. Spon, of London and New York, well worth perusal.

CHARGES FOR ELECTRICAL ENERGY

By Alton D. Adams



GREAT variations exist between the different rates charged for electric energy. These, though occasionally due to special circumstances, are based, in the main, on necessary factors of generation and distribution.

In the early days of central electric supply stations, and to some extent at the present time, charges were based largely on the total amount of service rendered to each consumer per month or year. The service under such a system of rates is often measured by the size, or nominal rating, of the electrical devices operated, rather than by the actual amount of energy consumed. For some years after systems of electrical supply had been inaugurated the principal service was that to arc and incandescent lamps. A scale of charges was made for each kind of light, according to the amount used by each customer, and these charges often involved widely different energy rates in the two kinds of service. Next came the electric motor, and different rates were again adopted for the energy which it required. Still later extensions of electrical supply included service to heating and cooking apparatus and a variety of chemical operations.

With the extending applications of electricity, charges have been more generally based on the actual energy sold, as determined by meter, rather than by the nominal rating of the apparatus served. Closely connected with the meter system of uniform charges per hour, for energy used in a certain kind of apparatus and to a definite amount per day or month, two important modifications have developed. On one plan the rates charged for electric energy vary with the number of hours during each day that the maximum demand of any customer on the central station service continues. Another basis for rates takes into account not only the number of hours per day during which the maximum demand continues, but also the particular times of day at which this maximum demand takes place.

To appreciate the advantages of these several charging methods, it is necessary to consider the conditions under which the public supply of electric energy takes place. As electric lighting is sub-

ject to demands that do not hold for other kinds of service, its requirements may be noted first. The unit generally adopted for the measurement of electrical energy is the kilowatt-hour. This corresponds to the amount of energy consumed by twenty ordinary incandescent lamps during one hour, when each lamp requires fifty watts. The public demand for light is far from constant during the twenty-four hours of each day, but is largely concentrated into a small fraction of the period. Those times of day that show the greatest demand for electric light are between 4 and 10 P. M., varying somewhat with the time of year. Whatever the output of a central station at different times of the day, it is evident that several of the expenses of the plant are constant, or as great as they would be if the machinery delivered its full capacity during the entire twenty-four hours. It is also clear that the working capacity of the station must be equal to the maximum demand, though that demand exist for only a single hour daily.

Among the fixed expenses of a plant are the interest on invested capital, salaries, rents, sinking fund and depreciation. After the plant has been operated during a sufficient number of hours each day to cover these fixed expenses, any further earnings are clear profits except for the small costs of fuel, water, and incidental items. It, therefore, follows that, so far as fixed charges are concerned, the cost of each unit of electric energy generated by a plant is less as the total number of units generated increases. The cost of fuel, water, and incidental supplies, on the other hand, is nearly constant for each unit generated, whether the total number of daily units be large or small. Any relation between the cost for fixed charges and for fuel, water, and incidentals is necessarily subject to variation; but it is safe to say that if a plant operated but one hour per day, and that at full capacity, the fixed charges would be as much as three-fourths of the total expense. If a fixed charge per unit of energy be made to every consumer whose monthly or yearly supply is the same in amount, it is evident that the rate of profit to the station will vary materially for different customers. Experience has shown that the period during which the maximum demand for electric energy continues per day varies from a fraction of one hour to as much as four hours with different consumers.

Under the older system of uniform rates to customers of equal monthly consumption, the electric stations actually lost money on those customers whose maximum demand continued for only one hour or less daily. Those customers who required their maximum supply during the largest number of hours per day were thus required to make up losses and to furnish the entire profit to electric systems. The system of uniform rates has in this way not only been unfair to some consumers, but has also operated to prevent extensions of electric supply, since large consumers found the service very expensive.

Electric stations are at a decided disadvantage, compared with gas plants, in the supply of a maximum demand during short periods daily, because gas-making apparatus can be worked continuously and the product stored in large amounts. Storage capacity at electric stations, in the form of storage batteries, is expensive, and usually corresponds to but a small part of the possible daily output from machinery. The system of charges, based on the daily period of maximum demand by each consumer, makes the average rate per unit of electric energy less as this daily period increases. In order to fix the maximum rate of charge so that it shall include all of the fixed expenses of an electric plant, it must be based on some assumed period of maximum demand per day. The time usually selected is one hour daily on an average. For any customer the maximum demand at any time during any period from one month to one year is ascertained by a suitable recording meter. The total kilowatt-hours or units consumed by the customer during the period for which the maximum demand is noted are also recorded by another meter. In one month the total consumption of electric units of energy,

divided by thirty, then gives the average number of units consumed per day, and these units per day, divided by the maximum rate of demand per hour, give the average number of hours per day to which the supply is equivalent at the maximum rate of demand.

For example, if the energy consumed by a customer be sixty electric units per month, and his maximum demand be two kilowatts, the average units required per day are two and the average daily period of service, one hour at the maximum rate of demand. If all of the fixed charges on the electric system are included in the rate for one hour of daily service, the charge for the first hour may readily be four times as great as that for each additional hour. Under such a system of charges, the longer the electric service is used per day the cheaper its average price becomes. This maximum demand system of charges yields the electric station a uniform rate of profit on sales to all consumers that use energy at their maximum rate of demand during not less than one hour per day. Customers who desire service of less than one hour per day, at their maximum rate of demand on the average, are still a loss when the highest rate is proportioned for one hour of service per day, but not to the same extent as when rates are uniform.

Conclusions as to the maximum demand system of charges are based on the assumption that the maximum demands of all consumers occur at the same time, so that the sum of all these demands gives the greatest load for the electric station and determines its capacity. Such an assumption, however, is not entirely correct, even for electric lighting loads, and experience has shown that the times at which different lines of business require their greatest amounts of light do not coincide. The only demands of consumers that increase the fixed charges at an electric station occur at the period of maximum station load. At any other times the demands of a single consumer, however great, serve to keep machinery at work that would otherwise be idle. As nearly all electric stations have their maximum loads at some period between 4 and 10 P. M., the maximum demand system works to the disadvantage of both the station and consumers, as to their heavy requirements at other times of the day. The consumer being charged too much, the station is deprived of paying business that it might have at a fair profit.

Another method of regulating charges for electric energy that avoids these objections, fixes the rates according to the time of day at which the service is rendered, without regard to the maximum demand of any one consumer. During those hours when the station is subject to its heaviest loads the rate per unit of energy is the highest. For the hours of lightest station loads the rate is the lowest. Each additional consumer at the period of maximum station load requires greater generating capacity, but each consumer during times of small load requires only a larger outlay for coal, water, and incidentals. The simplicity and fairness of this variation of rates according to the time of service are much in its favour, and the method is widely applied in some form. In some cases the time of day at which the service is required is known with sufficient accuracy to fix the rate. For other places electric meters are arranged so as to have the switches that connect them actuated by a clock, and each meter measures the energy during certain hours of the day.

Electric motor loads, unlike those of lamps, are fairly uniform on the average through the working hours of a day. Motors have, therefore, done much to lengthen the hours of heavy load at electric stations and to reduce the element of fixed expense in central station rates. The degree of pressure regulation required for electric lamps is not necessary for motors, and the latter can be operated at higher voltages than the former. Largely for these reasons, and partly because of certain competitive ones, the rates for electric energy to be used in motors are generally lower than those for service to lamps.

Electric heaters for cooking and industrial purposes, and, in a smaller

measure, for general warming, are now consumers of energy to a material extent For reasons similar to those named in connection with motors, the rates for energy to be used in electric heaters are much lower than for equal energy to lamps.

While the main intent here is to point out factors that influence the various charges for electric energy, it may not be out of place to name some actual rates. Electric systems, unlike gas companies, do not give their net rates out to the general public. In fact, there is so much variation of rates from the same station that it would be hard to make them all widely understood. For lighting, the range of average rates in the United States is from ten to twenty cents (5 to 10d.) per kilowatt-hour, while for motors and heaters about one-half of these figures applies. At one of the largest electric plants in the United States the average rate for all electric energy sold is very near to ten cents per kilowatt-hour. Energy from this plant is widely sold for motors at as low as five cents (2½d.) per kilowatt-hour. For charging the batteries of electric vehicles, energy is sold by this same plant at as low as three cents (1½d.) per unit, provided the supply is taken at certain hours when the station load is small.

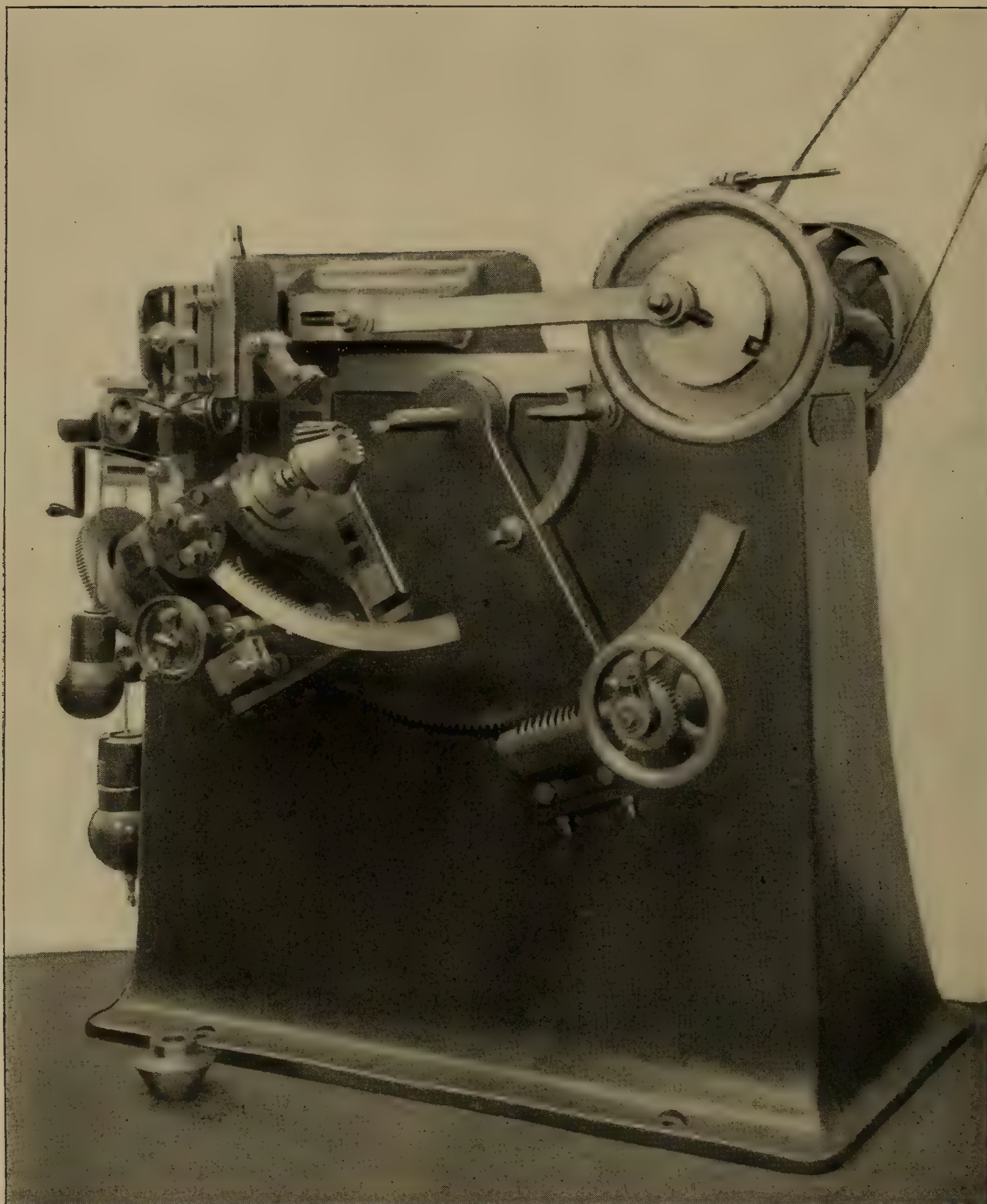
FOREIGN MACHINE TOOLS AT THE PARIS EXHIBITION

By Joseph Horner

WITH the immense number of machine tools shown at the Paris Exhibition it would manifestly be impossible to do more within the narrow limits of a magazine article than briefly notice a few of the more striking examples, and this idea the writer has tried to follow out, to the unavoidable exclusion, however, of many designs just as worthy of mention and illustration. British and American tools, of course, there are in profusion and of most interesting character, but all these, in this instance, it was thought well to omit and to take up, instead, those of foreign build.

To begin, then, it may be said that one of the most interesting exhibits of heavy tools in the French section is that of MM. Sculfort & Fockedey, of Maubeuge, Nord, representing a universal planing machine, in which the most conspicuous feature, as shown on page 67, is a massive forged steel holder, adapted to plane either longitudinally, transversely, or vertically, with provision for changing from one speed to another. The special value of this long, stiff bar consists in its capacity for planing within castings, and to a considerable distance away from the machine. A single driving spindle produces all the motions. The tool holder is balanced, and has a quick return. It will plane work on the floor, or bolted to the bed, its maximum longitudinal movement being 3 metres (9 feet 10 inches), its traverse 2 metres (6 feet 6¾ inches), and its vertical range 1 metre 400 mm. (4 feet 7⅛ inches). The feeds can be changed without stopping the machine. It is driven by a motor at the Exhibition, though not necessarily so in a workshop, for which a countershaft might be adapted.

Bevel gear planing machines are represented in various modifications. The one illustrated on page 66 is by the firm Le Progrès Industriel, of Brussels and Paris. The wheel blank is fixed on a mandrel which swings on a sector. The division for pitch is through worm gear and change wheels, and division plate, seen at the lower left-hand end of the machine. The cutting tool, the holder of which is reciprocated by the connecting-rod from the slotted adjustable crank disc, has a linear movement only, and the movements for vertical, or cone, and tooth flank angles are imparted to the blank. The main sector or quadrant plate gives the first, the former imparts the second, and the result is that the movements of the tool are always toward the apex of the pitch cone. The main quadrant plate upon which the swinging and dividing mechanism is carried is pivoted upon the standard, and the centre of its pivot is the apex of the wheel cone. It is regulated by the hand wheel and worm gear seen at the lower right-hand side, to give the feed for depth of cut, being fed by the hand wheel for quick adjustment, but with toothed wheel and ratchet during actual cutting. The arbour for the blank is carried in a hollow spindle, having its bearings in a



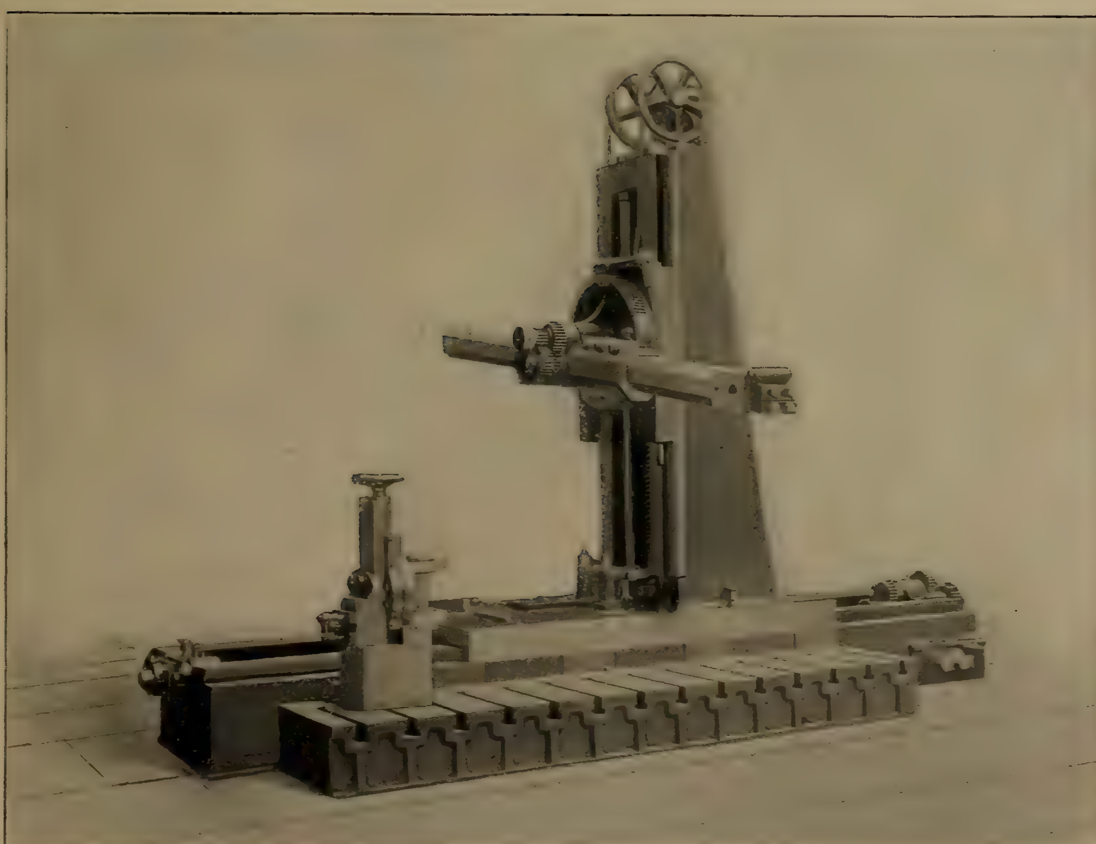
A BEVEL GEAR PLANER, BUILT BY LE PROGRÈS INDUSTRIEL, BRUSSELS AND PARIS

headstock which is adjustable on ways on the face of the quadrant plate. The sector rank receives the former,—seen at its upper end,—and it rocks upon the hollow spindle just named. This moves in unison with the former through the medium of a guide roller and weights, moving the blank between each cut.

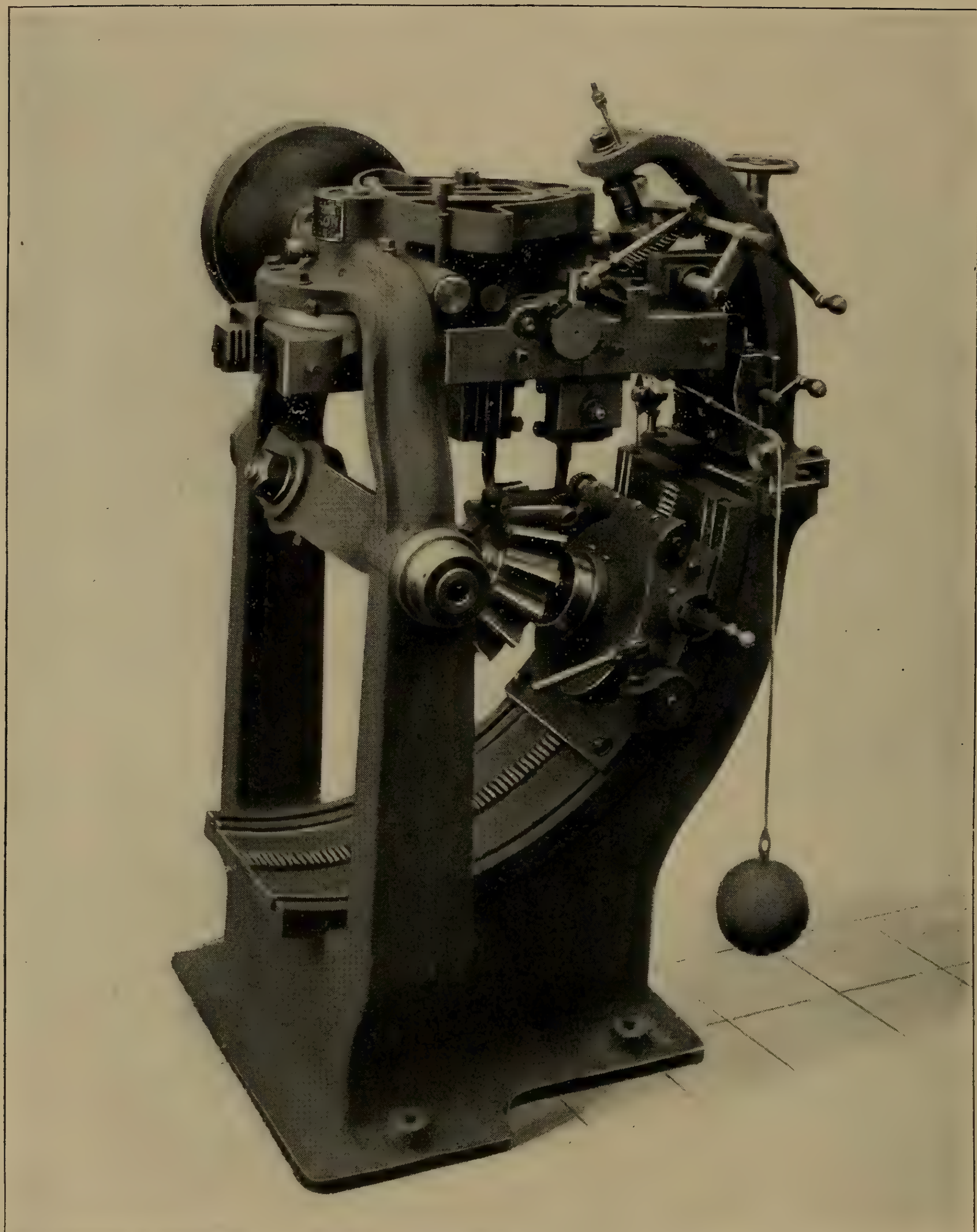
The Oerlikon Works, of Zurich, Switzerland, show a novel wheel planer, in which two arms or rams, operating alternately, cut both sides of a tooth at once. This is shown on page 68. A former is used to guide the arms, each one being pulled over against the former by means of weights. The machine planes bevel wheels up to 500 mm. (19 11-16 inches) diameter, and 200 mm. (7⅞ inches) breadth of face. The lower portion of the machine comprises a main framing, furnished with quadrant slides, and has a central rack. The saddle which receives one end of the wheel blank slides on this, being adjusted on it by means of the small ratchet handle seen in the illustration. It carries, in addition, a cross-bar, which

pivots, and is adjustable endwise in two bearings contained in uprights springing from the base of the machine. This serves as a support to the arbour on which the blank is fastened. The driving mechanism is placed in the upper part of the machine, and comprises a cone and shaft, with worm and worm-wheel, a crank disc, a double pinion, and a toothed sector, the details of which are mostly concealed. The double pinion actuates the two rack rams disposed below the gears, one of which is seen in the illustration, projecting slightly from its slide. They are furnished with supports for the tools and holders, adjustable in guides. One of these racks automatically works the feed mechanism. All these arrangements of gears, etc., are carried at one end by a support movable upon the vertical arms that spring from the lower frame, and at the other end by the support which carries mountings for the former, or templet tooth.

The work of planing wheel teeth is effected in the following manner:—The wheel blank is first attached to the saddle by means of an arbour of suitable size. This permits, by means of nuts, of endwise adjustment of the blank on it to suit different diameters of wheels. The arbour is adjusted until the upper edge of the gear blank to be cut is correctly set. The two tools are next put in place, and the former arrangements effected. The tool boxes and the wheel blank being fixed, the operation of cutting commences. The two tools, operated by movements in opposite directions, the one advancing, and the other returning, simultaneously attack the two flanks of the same tooth. Two counterweights ensure the constant pressure of the guiding knife edges against the templet, so controlling the movement of the tool-holder slides. The feeding of the tools is done automatically until one tooth is finished. They are then thrown out of action, the gear is shifted round a distance equal to the pitch, and the tools are brought back to their first position by means of a crank, ready to cut again. The division of the gear is



UNIVERSAL PLANING MACHINE, BUILT BY MESSRS. SCULFORT & FOCKEDEY, MAUBEUGE, NORD, FRANCE



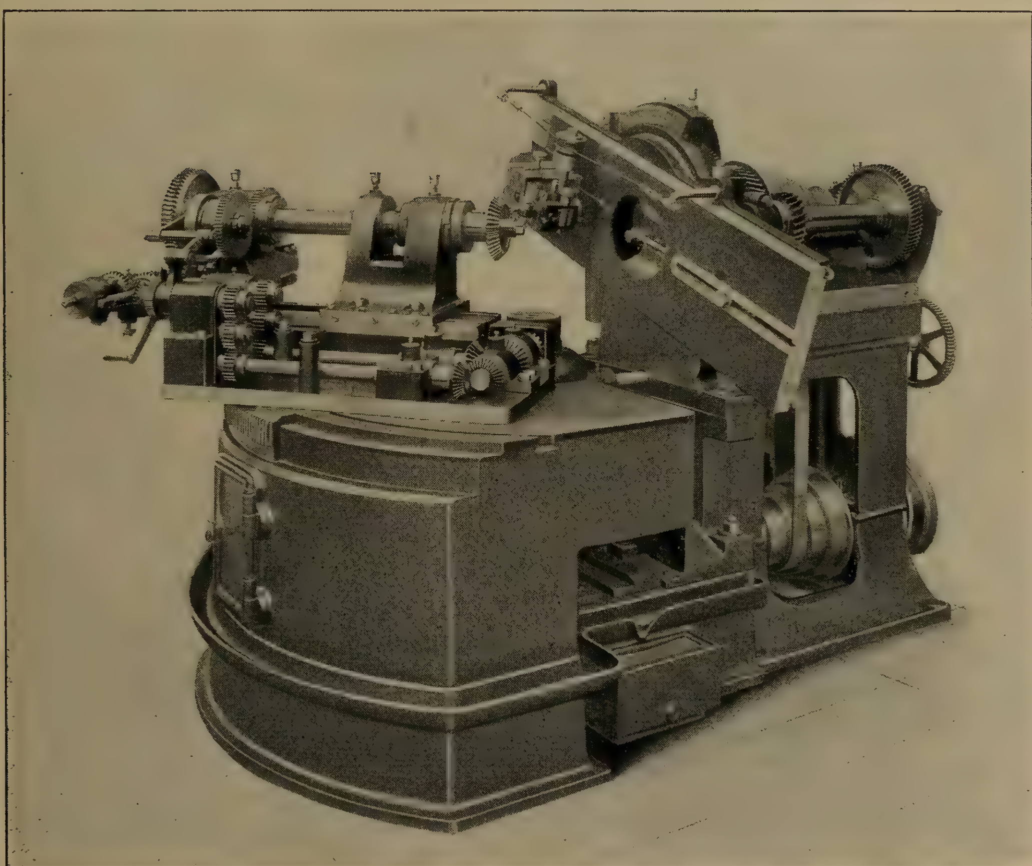
BEVEL GEAR PLANER WITH TWO TOOLS, BUILT BY THE OERLIKON WORKS, ZÜRICH, SWITZERLAND

done by hand, through change wheels. If it is required to cut the teeth in a solid blank, it is necessary to rough out the tooth space first with parallel grooves, for which purpose a tool holder with a straight, plain tool is supplied with the machine, to be fixed on a rack, set straightforward.

The firm of H. Ernault, of Paris, has on exhibition a bevel gear planer of the generator type, shown on page 69. The firm makes a specialty of its gear cutters, and this particular machine is but the result of many previous labours in this department. Without attempting to describe it in full detail, the following remarks will suffice to explain its principles of action. It resembles some American machines in this fundamental principle, that the teeth cut are generated by the construction embodied in the machine, and that the tool represents a tooth of a crown gear, that is, a bevel wheel the pitch plane of which is

an absolute plane. The wheel blank is rotated suitably while the tool reciprocates. But here its similarity to other machines built on this principle ends.

The wheel blank is carried on a horizontal arbour, seen at the left hand, the bearings and operating gears of which are mounted on a saddle pivoted on the base of the machine, and which can be set to any part of the quadrant to take gears of any angle. Motion is imparted to the blank in such a way that the cutting tool takes but one cut at a time on a tooth, after which it is withdrawn, the blank rotated to a distance equal to the pitch, and then a similar cut is taken on the tooth adjacent. The cord which is seen over the plate which carries the tool slide lifts the tool out from its cut while the blank rotates. The slide is moved by a disc and connecting-rod, which are operated by the cone pulley and back gears seen to the right. The slide plate also oscillates about its centre, after each cut, to suit the changing bevel angles. Thence it is transmitted through various spindles, some of which are seen in the illustration, to a worm wheel at the extreme upper left hand, and to the spindle on which the blank is set.

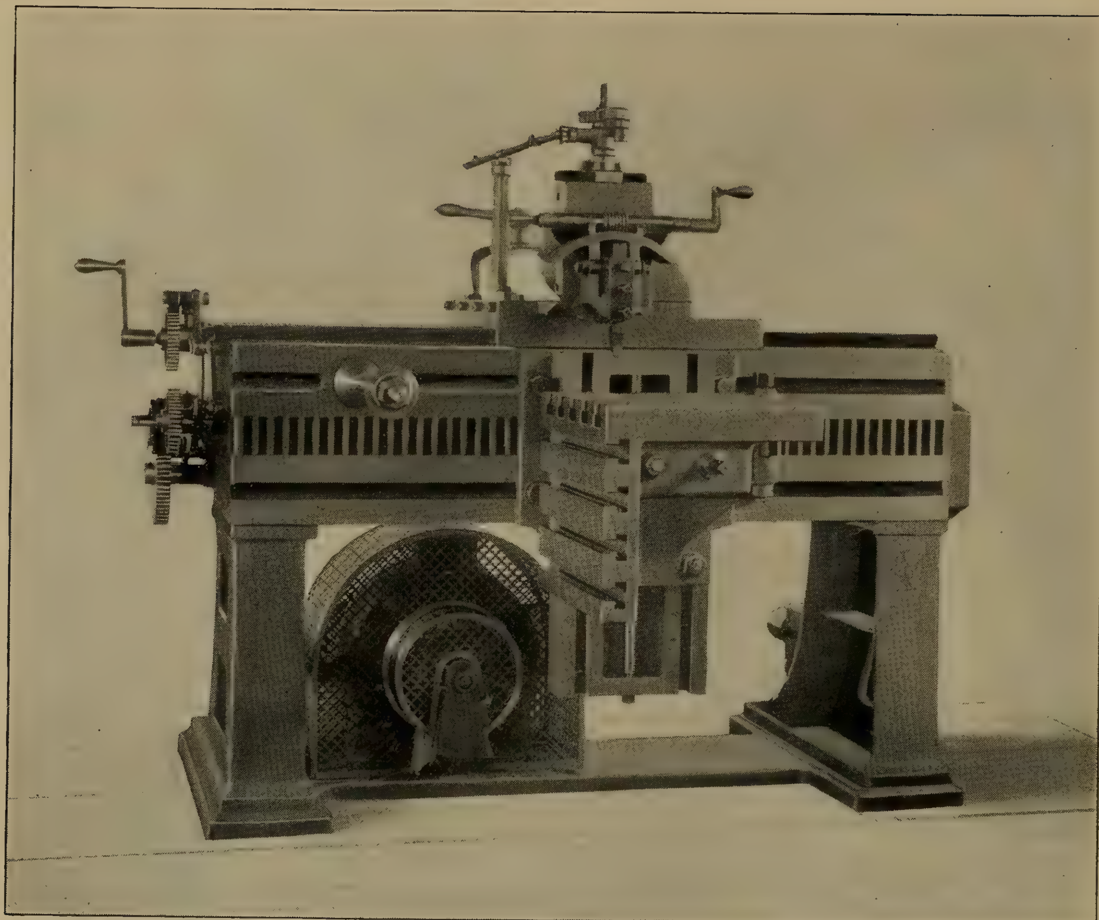


A BEVEL GEAR PLANER BUILT BY H. ERNAULT, PARIS

of the flanks. The slide is fitted with *V* edges, and its broad area is a notable feature, being made for permanent accuracy. The tool box lifts on the return stroke.

The movement of the blank is controlled from the change gears, one of which is seen projecting from the extreme right of the headstock. This detail cannot readily be understood without the aid of sectional views. But it is sufficient to state that the movement is conveyed by a shaft,—seen coming from underneath the head in the figure,—and is transmitted through bevel wheels to a shaft beneath the central pivot around which the work base

A curious feature is, that the blank is rotating slowly while the tool is planing, which results in imparting a helical twist



AN ELECTRICALLY-DRIVEN SHAPING MACHINE, BUILT BY THE DUCOMMUN WORKS, MULHOUSE, ALSACE

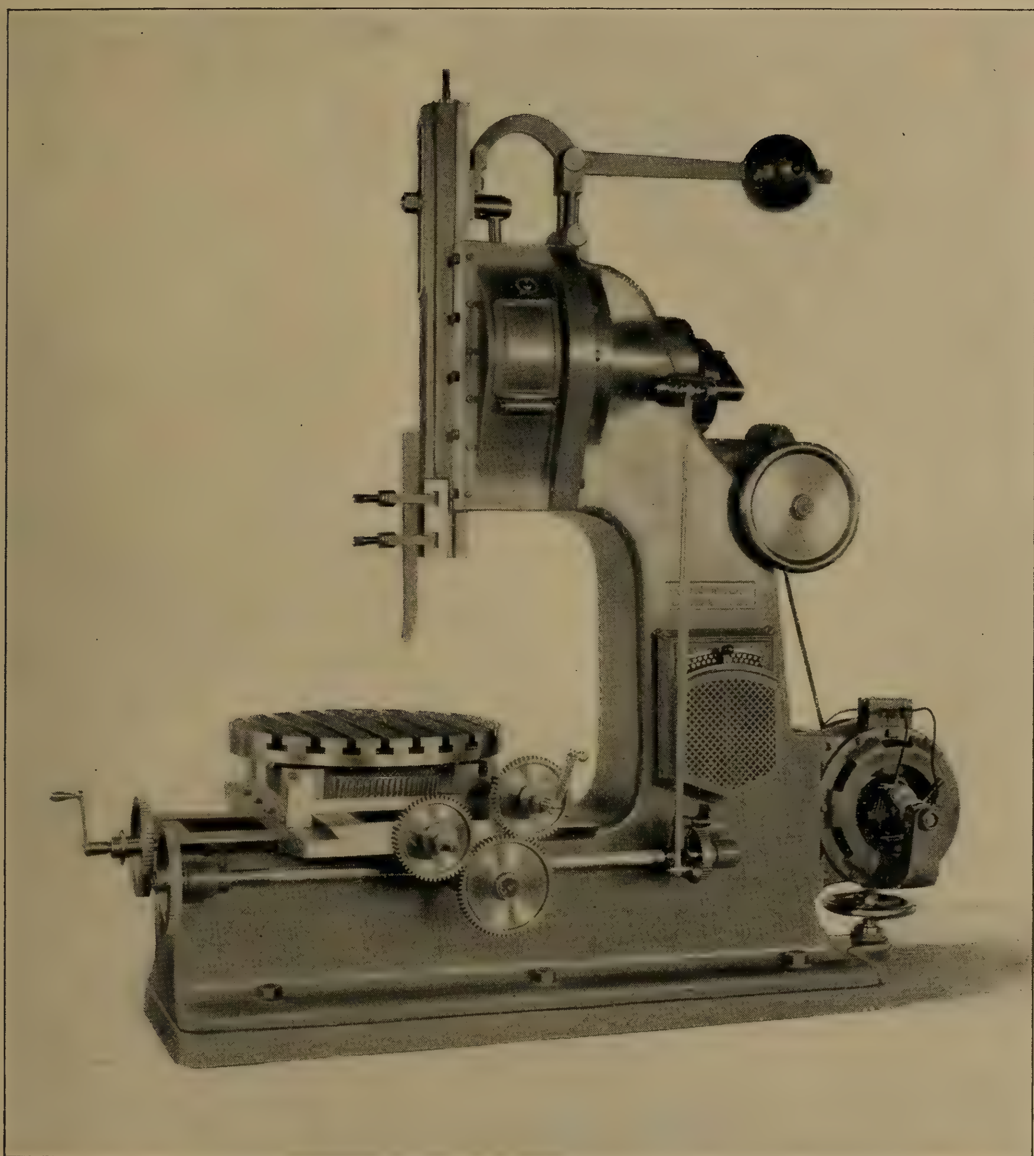
to the tooth face. But since the same twist, in opposite directions, is imparted to the matching teeth of a pair, there is no disadvantage, but rather the reverse in this. This machine was designed by M. L. Monneret, the engineering director of H. Ernault.

The Ducommun Works, of Mulhouse, Alsace, turn out some very well-made machine tools, representative of various types, including lathes, slotting, shaping, and milling machines, and milling cutters. An electrically-driven shaper shown by this firm is illustrated on this page. It is a massive tool, in which the slots, the rack, the saddle, and its bracket are of exceptionally stout dimensions. The motor is of the continuous-current type, of about 2½ H. P., making 1300 revolutions per minute. The cone,—four-stepped,—is placed at one corner on the far side of the machine, and speed is reduced through worm gear. In regard to the details of the machine itself, it has all motions as follows:—The traverse of the saddle is either by hand or power, through a screw and ratchet. The traverse of the ram is by crank, with a return of 3½ to 1. A variable length of stroke is adjusted by lever handle. A quadrant tool holder serves for planing concave faces, or faces at an angle, and an arbour, for convex surfaces. The down feed of the tool is imparted by power, by means of a rod with ratchet and adjustable stops. The dimensions of the machine are:—Length of bed, 5 feet 3 inches; maximum height between tool and table, 1 foot, 1¾ inches; longitudinal traverse of tool carriage, 3 feet 3⅜ inches; traverse, or stroke, of ram, 11 13-16 inches.

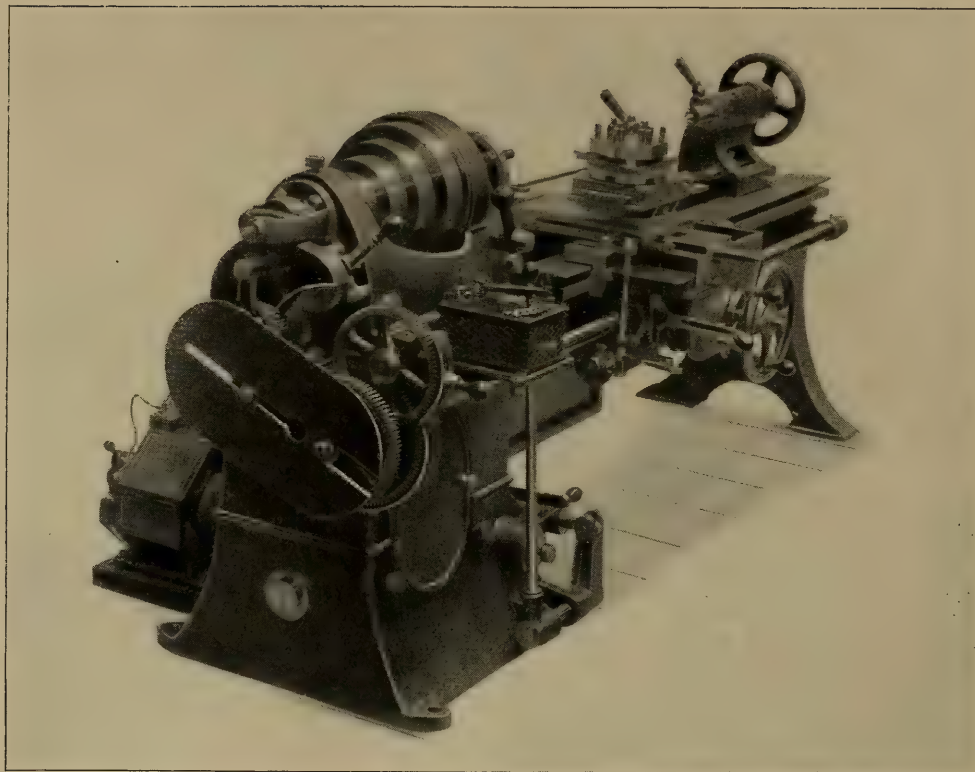
An electrically-driven slotting machine, of 300 mm. (11 13-16 inches) stroke, by the same firm, is shown on the page opposite. The 4 H. P. continuous-current motor is at the rear. It makes

1200 revolutions and drives a four-stepped pulley through worm and worm wheel. The ram has a quick return of four to one, and is balanced by a counterweight. The driving crank, with eccentric, to which the connecting-rod is attached, is neatly enclosed in the head of the machine.

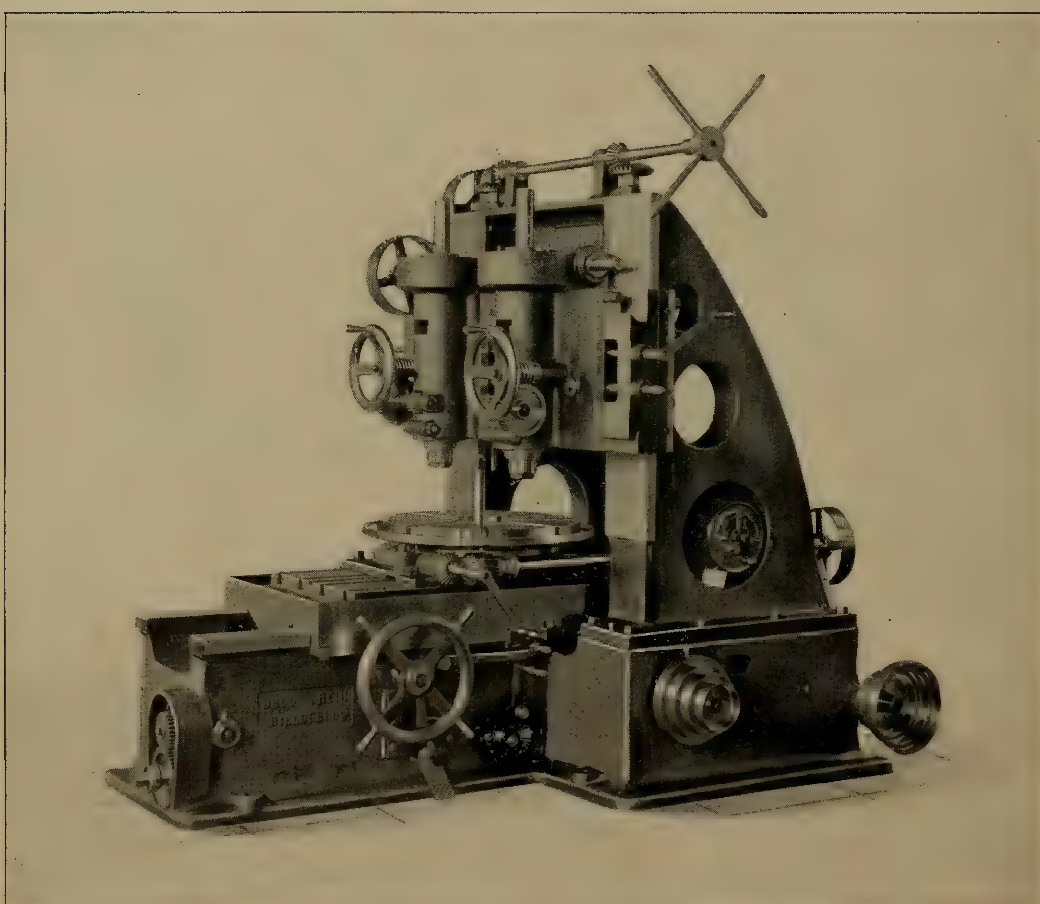
A small exhibit, but among the best in the Champ de Mars, is that of Messrs. Droop & Rein, of Bielefeld, Germany, comprising motor-driven machines. They arrest attention by reason of their proportions and various details, beyond the fact that they are motor-driven. The vertical milling machines of this firm are good specimens of high-class German machine tools. The double-spindle milling machine shown on page 72 is driven by a motor fastened to a bed plate behind the machine, whence it drives to a belt pulley with a tightening arrangement, details which are not seen in the view given. The great width of the cross-slide is noticeable. The spindles are driven by worm gear, and their end pressure is taken by hardened balls and rings. The worm shaft is driven by a belt, equal tension in which is maintained at all heights of the crosshead. The table feed is through special gearing, at eight different speeds,



AN ELECTRICALLY-DRIVEN SLOTTING MACHINE, BUILT BY THE DUCOMMUN WORKS



A LATHE BUILT BY THE UNION MACHINE TOOL WORKS, CHEMNITZ, GERMANY



VERTICAL MILLING MACHINE BUILT BY MESSRS. DROOP & REIN, BIELEFELD, GERMANY

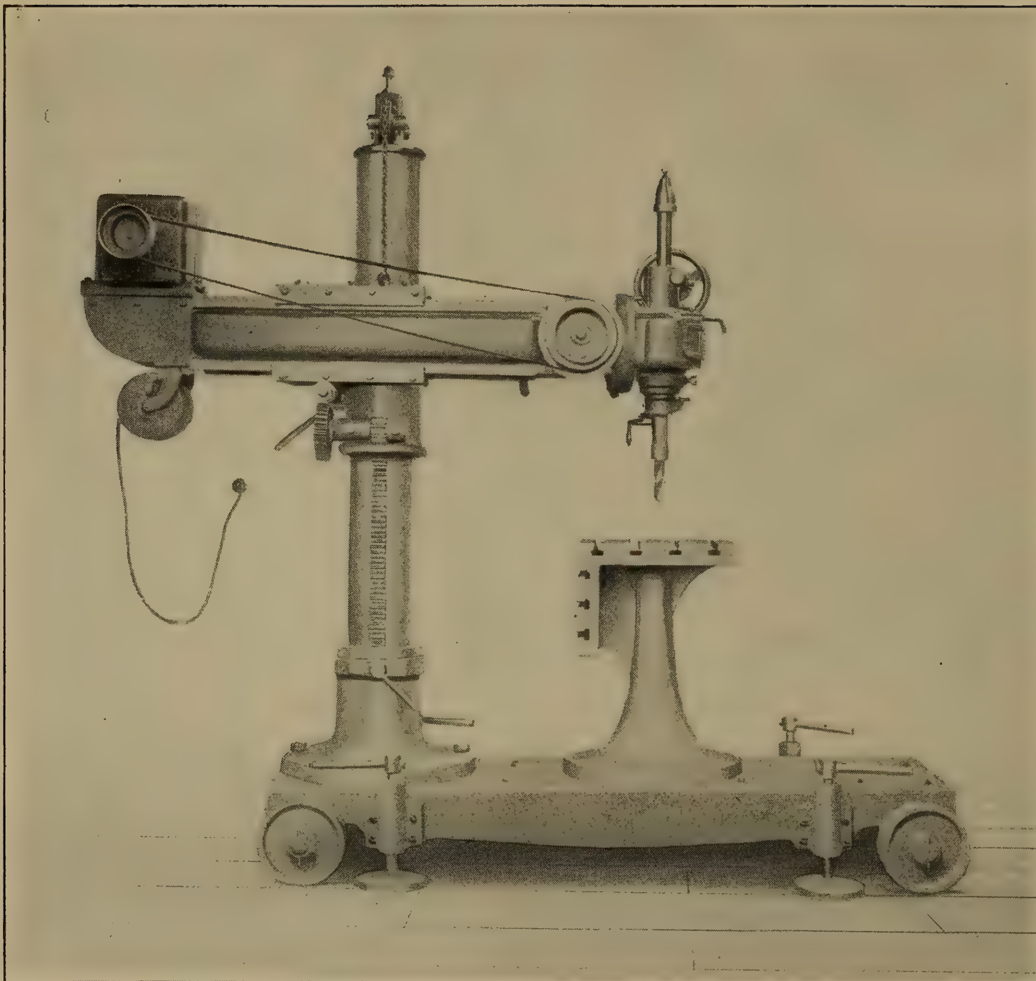
and is provided with reversing and automatic devices. All levers for operating the machines are brought into positions which are most handy for the workman. The circular table can be removed when desirable.

Messrs. Droop & Rein have a novel milling cutter for face milling, which they claim to be superior to those with inserted teeth. It is made by bending and welding a ring of flat tool steel, and cutting the teeth in one edge, being suitably relieved in a relieving lathe. It is held in a hollow head or holder with taper shank by means of a conical plug, corresponding in form with the inside of the ring.

The Union Machine Tool Works, of Chemnitz, Germany, exhibit a lathe which possesses several novelties, being in some respects unlike any other. A peculiar feature is that the ways on which the carriage slides are shouldered down below those which carry the heads and are protected by means of covering plates. It has also a triangular turret on the carriage, so that two tools can be brought close together, either for boring steps of different diameters, or for roughing and finishing. The lathe is electrically-driven, and the gears for driving and reversing are situated in the base of the hollow box standard under the headstock, the reduction in speed being by spur gears in this case, instead of by worm and worm wheel. The back gears are also placed below the headstock, instead of at the rear, a practice which has been adopted in a few American lathes. The top gears are encased in sheet iron. In order to permit one man to attend to several lathes, there are arrangements of stops by which any number of articles can be turned to exact lengths, and also automatic throw-out by means of stops, either for the rack or the lead screw, and at five different spots, irrespective of rate of advance. These are effected by means of a slotted bar at the front of the bed in which the stops are set, and a stepped disc which throws out the feed. There is also a throw-out for the cross-feed; an indicator for screw cutting, to fix the spot at which the nut must be closed on the screw after running back; a taper-turning attachment, at the rear, and various accessories, including a second rest, and travelling steady-rest, attached on the hind part of the carriage for shaft-turning, working in conjunction with the front rest. This lathe affords a fine example of German specialisation on original lines.

PORTABLE DRILLING AND TAPPING MACHINE, MADE BY MESSRS. COLLET & ENGELHARD, OFFENBACH-ON-THE-MAIN, GERMANY

Several firms make a great specialty of electric driving of machine tools. Among these mention should be made of the German firm of Collet & Engelhard, of Offenbach-on-the-Main, whose tools are all driven thus, their exhibit



A PORTABLE RADIAL DRILL, MADE BY MESSRS. COLLET & ENGELHARD

including a few selected examples. A portable type of universal radial drilling machine, shown on this page, represents one of these. A cast-iron base is carried on wheels for transportation to any part of a works. When set up for use, the wheels are lifted off the ground by means of four screws in cast brackets bolted to the sides of the base. The bottom ends of the screw spindles are provided with discs that rest upon the ground, and which, being adjustable by the screws, afford a firm and level support to the machine. The column pivots in the base, and the arm slides along the column, upon which it is counterbalanced. The spindle is 50 mm. (1 15-16 inches) diameter, and can be operated at a distance of 1000 mm. (39⅜ inches) from the column, and at the same maximum height. The motor serves partly to counterbalance the weight of the arm. The current is brought through a cable over a roller seen just below the motor, upon which it winds or unwinds to connect up to any convenient spot with longer or shorter lengths of cable. Deep work can be bolted direct on the base, shallow work on a table attached to the base.

Another portable machine, shown on page 73, is used for drilling and tapping, and is of special value in boiler and erecting shops, saving the tedious operation of setting work under a fixed machine or drilling by hand. The drilling spindle is driven by a one horsepower motor, which drives through helical gear, turning the spindle in both directions at four different speeds, permitting of tapping to a maximum diameter of 40 mm. (1 9-16 inches) and drilling to 60 mm. (2 5-16 inches). A

triple-headed, electrically-driven machine, of the same make, for milling and slotting locomotive frame plates is capable of operating on several plates up to a maximum thickness of 200 mm. (7⅞ inches). Each head is driven by a 2½ to 3 H. P. motor, that actuates either the milling or the slotting spindles. The movement of the arbour from the motor is through rawhide pinions.

Generally speaking, if we do not find many new machines, we note improvements on well-known standard types, and the results of the incessant pressure of competition are seen in some of the best machine tools.

Current Topics

Polyphase currents for electric traction service, though but meagerly represented in the lists of existing electric railway installations, have not been altogether at a standstill, and since the building of the first commercial polyphase railway plant at Lugano, in Switzerland, in 1895, additions have gradually been made to the number of similar installations. One of these is the Burgdorf-Thun Railway, in Switzerland, of which a somewhat detailed account was given in a paper recently read before the British Institution of Mechanical Engineers by Professor C. A. Carus-Wilson. This line links together three of the main lines radiating from Berne, namely, those to Olten, to Lucerne, and to Interlaken. The first of these is met at Burgdorf, the second at Konolfingen, and the third at Thun. The distance from Burgdorf to Konolfingen is sixteen miles, and from Konolfingen to Thun is nine miles, making the whole line twenty-five miles in length. It is of normal gauge, and carries the ordinary rolling stock of the other Swiss railways to which it is connected. The power house is situated at Spiez, at a distance of five miles from Thun, the generators there turning out current at 4000 volts, which is raised to 16,000 volts in step-up transformers. The current is carried at this tension from the power house along three overhead copper wires, about one-tenth of an inch in diameter, to step-down transformers situated at intervals of two miles along the line between Thun and Burgdorf. The current is there transformed down from 16,000 volts to 750 volts, and carried from there to two hard copper trolley wires, 8 mm. in diameter, and to the rails which take the place of the third wire. From the trolley wires two sliding contacts convey the current to the carriage motors, the third connection being through the

wheels of the carriages. Each carriage is equipped with four motors, two on each bogie, geared to the axles. Each of the motors is rated at 64 H. P., and, when acting together, they are able to propel the 32-ton carriage and a 12-ton trailer up the maximum grade of 1 in 40.

It may not be uninteresting to briefly repeat here some of the points which are in favour of polyphase railway motors. One of them, as given by Professor Dugald C. Jackson some time ago in an article in this magazine, is their action in holding back, by returning energy to the feeders, when they are driven above speed by a car running down hill. This action is entirely different from any that may be simply gained in series-wound continuous-current motors, but is analogous to the performance which would be shown by shunt-wound motors under similar conditions if they could be satisfactorily adapted to the requirements of electric traction. The action is very simple, and is a safeguard which cannot be overestimated for cars operated over heavy grades. We will suppose that a car approaches a dip in grade with the motors working. Upon entering the grade, it is natural for the speed of the car to increase, which, with continuous current, series-wound motors, will continue until the speed quickly becomes dangerous unless the motors are cut off and the brakes applied. A failure in brakes under these conditions has often resulted in frightful accidents. Not so with induction motors! As the car increases in speed the forward rotary effort of the motors decreases and gradually and smoothly changes into a retarding effort, while the power given up by the car as it coasts down hill is automatically returned by the motors to the line. Thus the power of the descending car is automatically placed where it may be usefully applied in operating other cars, instead of being frittered away in wasteful and injurious friction between brake-shoes and wheels. All this is done by inherent action in the motors themselves and is entirely independent of fallible humanity, represented by the motorman. Stops may be made on a grade in the usual manner by cutting off the motors and applying the brakes, and starting is accomplished by the ordinary process, after which the motors may again be left to care for themselves. It is interesting, further, to note that polyphase alternating-current railway plant, properly installed, removes much of the difficulty from electrolysis of water pipes and other underground metallic structures, notwithstanding the use of the rails for one branch of the circuit; but, on the other hand, in the line construction are involved all the difficulties of the double trolley.

A POLYPHASE ELECTRIC MOTOR CARRIAGE ON THE BURGDORF-THUN RAILWAY, SWITZERLAND

In a partial way at least the question of coal consumption of the turbine torpedo-boat destroyer *Viper*, now the fastest vessel afloat anywhere, has been answered by the results of her recent

official steam trials, during which her speed was 33.838 knots. This is not the best of which she is capable, her maximum on a previous occasion having been 35½ knots, or practically 41 miles an hour; but it more than satisfied the contract conditions. As the power developed could not be determined, the coal consumption per hour for a given speed was taken as a measure for comparison. On a three hours' trial at 31.118 knots the *Viper* burned 8.86 tons of coal per hour, or 19,846 pounds, and on a three hours' trial at 33.838 knots the consumption was 25,685 pounds per hour. The *Albatross*, which was built and engined by Messrs. Thorneycroft, is the only destroyer with reciprocating engines which has on official trials made a speed approaching to that of the *Viper*, and here the speed was 31.552 knots, with the engines indicating 7732 horse-power. The displacement of the *Albatross* is 384½ tons, and of the *Viper* 385 tons, while the coal consumed per hour for 31.552 knots for the former was 17,474 pounds per hour, and for 31.118 knots of the latter 19,846 pounds per hour, so that here is a fair basis of comparison which requires no comment. The 30-knot destroyers, with reciprocating engines, consume about 15,150 pounds per hour, this result being the mean of forty-five boats.

The energetic attempts that have been made of late to introduce a water-tube boiler of some kind into merchant ships lend special point to some information recently supplied by Mr. C. H. Wilson, of Hull, in the course of the British House of Commons debate on the Naval Estimates. It took the form of a brief history of the proceedings of Mr. Wilson's firm in fitting water-tube boilers to the ships of the celebrated Wilson Line. About eight years ago, as told in *The Engineer*, of London, Babcock & Wilcox boilers were put on board the *Nero*, and have been at work ever since. Up to July 17 of this year she has steamed, Mr. Wilson told the House, 166,000 knots. In 1895 a new steamer, the *Hero*, was fitted with similar boilers, and steamed 131,000 knots. In 1896 the old cylindrical boilers were taken out of another steamer and replaced by water-tube boilers. She has made 104 voyages, and run 106,293 knots. In 1897 the same thing was done with the *Orlando*, which has made sixty-eight voyages, and run 84,306 knots. In 1898 the old cylindrical boilers were taken out of the *Rollo*, and water-tube boilers substituted, and she has made forty-nine voyages, and run 53,975 knots. In 1898 the *Otto* was built for the short weekly Continental trade, and was fitted with water-tube boilers. She has made ninety-nine voyages, and run 51,984 knots. In the same year the *Truro*, a new vessel, was fitted with water-tube boilers. She has made ninety-four voyages, and run 51,291 knots. In 1899 the cylindrical boilers were taken out of the *Tasso*, and water-tube boilers put in. She has made twenty-seven voyages, and run 44,046 knots. This steamer makes frequent voyages from Hull to the West Coast of Norway. Summing up the results, it is found that the ships have made 800 voyages, and run 700,000 knots, and have given very little trouble. This is a record with which any maker of water-tube boilers may be well satisfied. The great advantage secured has been the saving in weight. In one of the Wilson liners, for example, the water-tube boilers and water in them weighs fifty tons less than Scotch boilers of the same power and the water in them.

The principal fact brought out by inquiry to determine to what Mr. Wilson's success was due is that in the Wilson boats the boilers never are forced. This, according to *The Engineer*, is the key of the puzzle, the solution of what has in some quarters been looked on as a mystery. Ample boiler power is provided, and the boilers can, so to speak, take their own time. The Scotch marine boiler supplying triple-expansion engines will develop about 1

indicated horse-power for 3 square feet of total heating surface, and 11 indicated horse-power per square foot of grate. Of course, higher and lower results are common enough, but the figures here given represent a good average performance. Now the water-tube boilers in the Wilson Line have nearly double this amount of heating surface. Thus, for example, the *Nero* has 5 square feet of heating surface per 1 horse-power. The *Hero* has 4.4 square feet; the *Cameo* and *Orlando*, with a surface of 4.4 square feet and 4.5 square feet, have given more trouble than any of the others, because, it is stated, they were originally made too small for their work. If space were available the surface ought to be 6 square feet per horse-power. The *Martello* is the most economical of all the ships. Mr. Hide, the superintending engineer of the Wilson Line, states that any attempt to obtain more than 1 horse-power from 5 square feet of surface, or to burn more than eighteen pounds of coal per square foot of grate per hour, has been attended with loss of economy and trouble with the tubes next the fire. There are no fewer than nine large steamers of the Wilson Line now doing well with Babcock & Wilcox boilers.

THE truth is, concludes *The Engineer*, that the water-tube boiler, like every other boiler, has its limitations. Unfortunately, this truth is put on one side. The British Admiralty put it on one side. They attempted to get out of the Scotch boiler a duty of which it was wholly incapable. The result was total failure, not because the boiler is a bad one, but because its limits were not recognised. It has been and is still almost impossible to persuade the water-tube boiler men that the limits of each and every type are very rigidly fixed indeed. The enthusiasm of inventors has carried them away. They have persuaded steam users that their boilers could do what was really impossible. The result has been failure, and the ruin of the reputation of the boiler. It is the old story,—reason disappears in a mist of verbosity. The water-tube man persuades himself, and would persuade the world if he could, that a foot of heating surface in his boiler is at least as good as a foot in any other boiler. It is nothing of the kind. The water-tube boiler is a very excellent steam generator; but to make the most of it we must fully understand, not what it can do, but what it cannot do. Even when it is as big as it must be, Mr. Wilson's experience shows that it is better than the Scotch boiler,—as much as £1500 to £2000 a year better in one ship, according to Mr. Wilson's figures. He is content to save 50 tons while the indiscriminate advocate of the system would save 100 tons, with the result that the boilers would be turned out of the ship in six months. The water-tube system has suffered infinitely more from its friends than from its enemies.

THE Government of Spain has issued notice that in the railway, mail, telegraph, telephone, and steamship service of that country, and in all ministerial offices, the courts, and public works, the computation of the hours, after the first of next January, is to be made by the numbers 1 to 24, beginning at midnight. Midnight will be designated as 24, but for the next 59 minutes a cipher will be used; for instance, 12:30 will be called 0:30. Greenwich time is to be the standard.

CONVEYORS of the endless belt or chain type, with either actual belts as the transporting media, or plates carried by chains or wire ropes, moving in troughs, or similarly suspended buckets going in ceaseless rounds, have become so characteristic of machinery of this general class that any innovation of the kind shown in the annexed sketch excites immediate interest. In this we have a reciprocating conveyor instead of one with motion constantly in one direction, and the conveyor blades, or flights, are simply like so many pistons

moving back and forth in a trough, pushing the material in the trough forward during one stroke, and lifting, on hinges, like flap valves, and sliding back over the material without moving it during the return stroke. The illustration makes this action clearer probably than words could do it. The conveyor blades are suspended from a continuous member, in the shape of a pipe which insures great stiffness, and this pipe is supported by guide frames which fix its position vertically and make the floating of the blades on top of the material impossible. There are also guide axles with flanged wheels to fix the position of the pipe laterally. The conveyor blade frames are attached to the pipe by U clamps, and each blade is connected to its frame by a flexible hinge, usually made of harness leather, which, owing principally to the disposition of frame prongs as shown, has no appreciable strain of any kind thrown upon it, and therefore will last a long time. While the outfit complete appears to have some limitations in its application which will readily suggest themselves, it is an interesting departure from what has for a long time been an apparently set style of conveyor practice. It is made by Messrs. Heyl & Patterson, of Pittsburgh, Pa.

A RECIPROCATING CONVEYOR

THE coal consumers' panic in the United States during the past few weeks, brought on by the extensive strike of the Pennsylvania coal miners, has helped to exhibit in a marked way the mutual interdependence of the various parts of the social system, and the disastrous results of a failure or neglect by any one of them to fulfil its function in it. Discoursing on this recently in the New York *Sun*, Matthew Marshall said:—Ages have elapsed since a man and his family could supply their wants without help from without. The savage might, at first, build his own hut, make his own hunting and fishing implements and thus obtain food, while his wife and children might make his garments and perform all necessary household and agricultural work, so that by their united efforts they could all subsist. At a very early period, however, labour began to be diversified. One set of men undertook one kind of work and another another, and each, by devoting himself to his special branch, acquired in it a skill and a facility of production which enabled him to furnish his neighbours with better and cheaper commodities than they could manufacture for themselves. The process of differentiation thus commenced has never ceased, and now, as we see, every individual looks to other individuals for hundreds of things which he does not himself produce. In the construction of the humblest home a host of skilled mechanics, such as masons, plasterers, carpenters, iron workers, tinsmiths, plumbers, painters and glaziers, and the like, are employed, and on the scantiest table are spread articles of food and drink brought there from various parts of the globe. To furnish the 50,000 tons of anthracite coal consumed daily in the city of New York alone, thousands of miners must dig it out of the earth, and to distribute it, many miles of railroad must be built, and

great numbers of cars and engines must be constructed and used. So it is with everything that enters into the details of daily life. We are all servants of one another, and when any one of us neglects or refuses to render his allotted service the rest must suffer.

OUR familiarity with the existing machinery of industry renders us insensible to its exceeding complication, and we fail to comprehend its widely ramified extent. Only the threat of a calamity like that of a stoppage of our daily coal supply startles us into reflecting upon it. As we get the service of steamships, railroads, telegraphs, and telephones, and as we enjoy the innumerable articles of luxury that mechanical and manufacturing inventions have made so plentiful and so cheap that we have come to treat them almost as necessaries, we give no thought to the fragility of our hold upon them. A suspension of the mining of coal alone, if it were universal, would paralyse the railroads, the electric light works and all kinds of manufacturing industry, besides depriving us of the means of warming our houses and cooking our food. A similar suspension of the daily service of butchers, bakers, milkmen, and grocers would bring us to the verge of starvation, and if domestic servants even were unanimously to abandon their work, their employers would, for a time at least, be unable to carry on their housekeeping. A general strike of cashiers, bookkeepers, and clerks would, in like manner, bring mercantile and financial affairs to a standstill, and one of mechanics and labourers would stop all building operations. The promoters of strikes like that of the Pennsylvania coal miners are, therefore, attacking the whole community. The mischief they do extends far beyond the immediate field of their operations and reaches multitudes who are powerless to protect themselves against it. As yet, no means which would not do more harm than good have been suggested for preventing such assaults upon the industrial fabric. The problem of so adjusting the relations of employers and employed that there never shall be conflicts between them yet awaits solution, and in the meantime we must bear the consequences.

ABOUT once every four or five years the gunpowder engine bobs up for consideration, with more or less irrational claims behind it for superiority over everything else existing in the prime mover line. It is with us again just now, this time in connection with an automobile which is to be driven by it "with economy and despatch." For ordinary factory driving, and for the propulsion of yachts and other craft, the claims and the disappointments of the gunpowder engine have become so familiar that its advent in the new field of automobilism carries with it almost a refreshing sense of novelty. But with its old-time perversity the motor is not likely to stir up much faith anywhere.

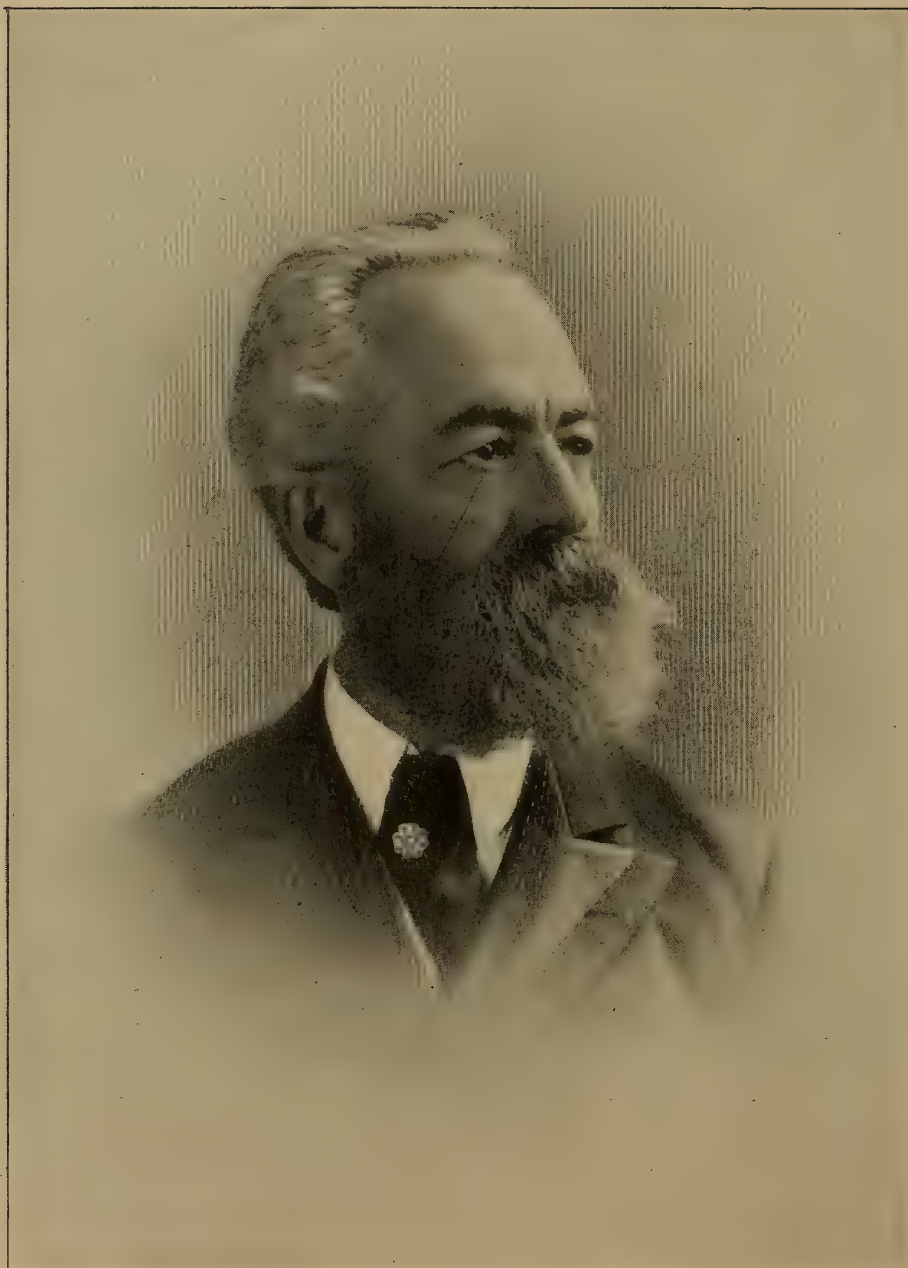


PHOTO BY J. F. RYDER, CLEVELAND, O.

Chas. H. Morgan

THE RETIRING PRESIDENT OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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ELECTRICITY AT THE PARIS EXHIBITION

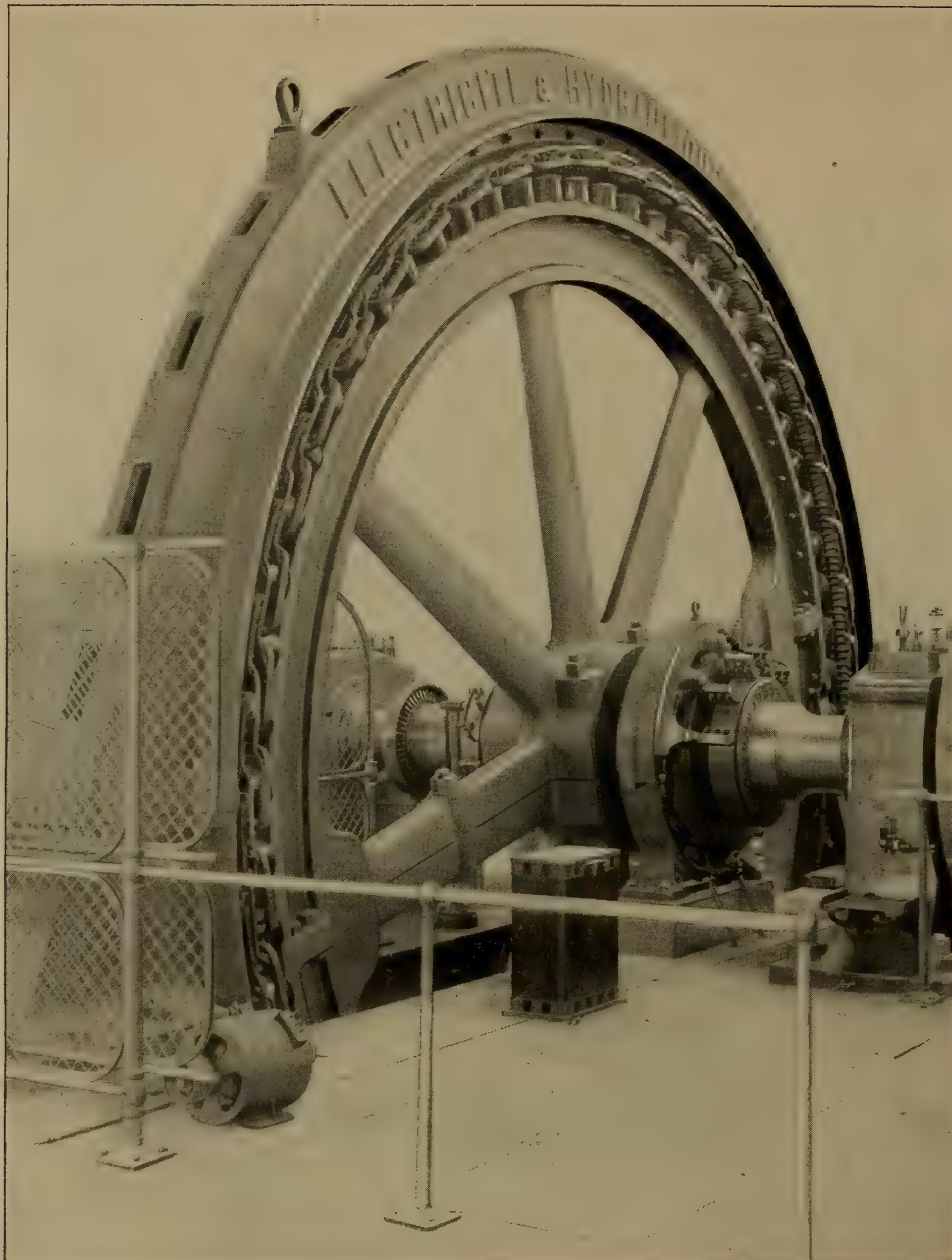
FROM A BRITISH POINT OF VIEW

By C. S. Vesey Brown

ONE result of the Paris Exhibition of 1900 promises to be the standardisation of the systems for generating electricity, and it is not too much to say that in the future electricity will be generated all over the world by either three-phase alternating current at from 2000 to 6000 volts, with fifty periods, or continuous current at 500 to 550 volts, depending on the area and the power to be supplied.

The latter system is now very extensively used in Great Britain, but the former has yet to be firmly established in place of single-phase current, and in this respect it is interesting to note that on the Continent, where single-phase alternating current machinery was installed when that type of dynamo and its accessories became more widely known, extensions and additions to plant are now made with three-phase machinery, and the current is either transformed to continuous current at 500 volts, or is used direct in the distributing systems after being transformed to from 100 to 350 volts.

There were a few single-phase alternators in the Exhibition, used almost entirely for lighting purposes, with a few isolated cases of single-phase motors working with condensers. These, however, simply served to show up the superiority and flexibility of the three-phase system. The standard pressure for alternating work is from 2000 to 2200 volts, and for continuous-current work from 500 to 550 volts, distributing direct to a three-wire system. There are, of course, variations in these pressures. Some alternators generate as high as 6000 volts, and there are a few



THREE-PHASE ALTERNATOR, BUILT BY THE SOCIÉTÉ ANONYME D'ÉLECTRICITÉ ET HYDRAULIQUE, CHARLEROI, FRANCE.

manufacturers who make a specialty of dynamos generating direct at 15,000 volts; but the usual plan appears to be to generate at from 2000 to 6000 volts, depending on the distance of the generating station from the area to be supplied with current. In the continuous-current exhibits a few of the machines were made for 250 volts, and amongst these were two shown by British firms.

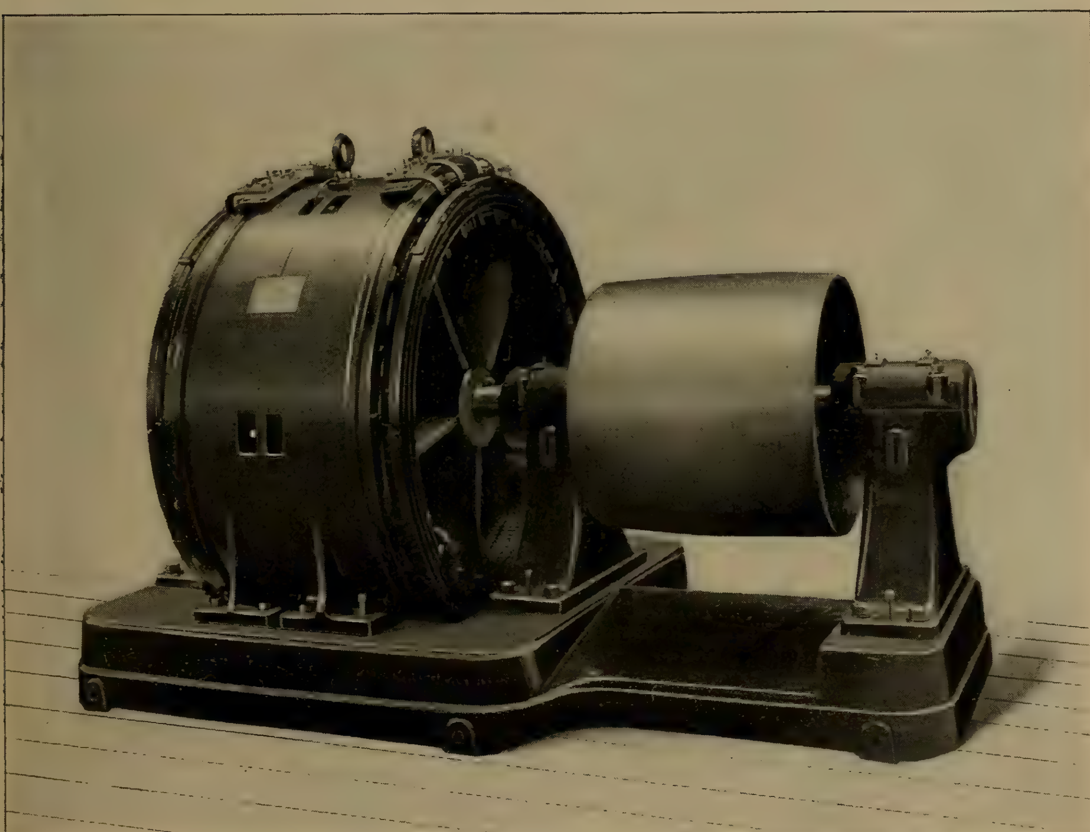
The lighting and power circuits at the Exhibition were very simply arranged, and there was no attempt at any special switchboard novelties. The Exhibition authorities arranged to provide steam and condensing water and a certain payment to those firms who would undertake the supply of current for lighting and power purposes, and about thirty-eight firms availed themselves of this arrangement to show their dynamos at work. There were two large distributing switchboards, one for alternating and one for continuous current. The alternating current was delivered to any part of the Exhibition at

high pressure, and was then transformed for either lighting or power. There was no attempt at running the alternators in parallel. The continuous current was transmitted to a three-wire system, with 500 volts between the outer conductors. All the regulation was done at each dynamo and not at the switchboards.

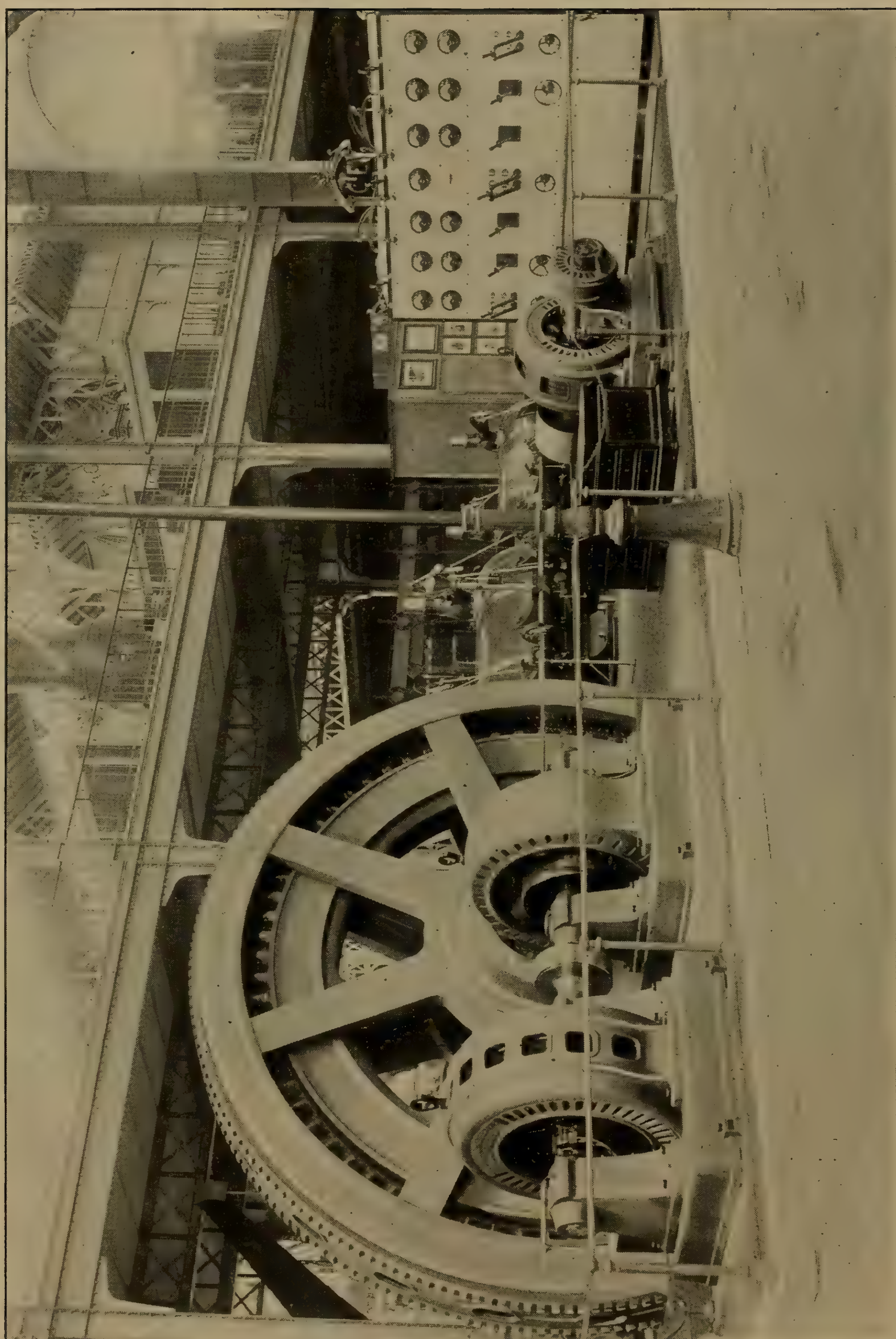
The total energy supplied in the Exhibition varied from 7000 H. P. in the daytime to 20,000 H. P. on fête nights, of which the illuminations of the magnificent water fountain called the "Chateau d'Eau" absorbed about 1200 H. P. The illumination of the Eiffel tower and the power required for the electric railway and the moving platform are not included in these figures, as they were supplied from separate works.

In recording the impressions of a comparatively short visit to the Exhibition, a description of the apparatus seen and the methods adopted for generating and using electrical energy must partake somewhat of the nature of a catalogue, and as the names of makers must of necessity be introduced, this opportunity is taken to thank the representatives of the various manufacturers for their kindness and courtesy in assisting to collect the data given herein. On the principle that three-phase alternating current was the standard arrangement adopted by the Exhibition, a description of the generators used for this purpose is desirable, as showing the variation in ideas and designs of different nationalities.

In the French, Belgian and Swiss exhibits the dynamos were, as a rule, coupled direct to slow-speed engines, of the type known in Great Britain as mill-engines. Generally the dynamo was mounted between the two cranks of a compound or triple-expansion engine. One of the oldest electrical manufacturing companies in France is the Société Gramme, and the 300-KW three-phase, belt-driven alternator illustrated on this page is typical of that

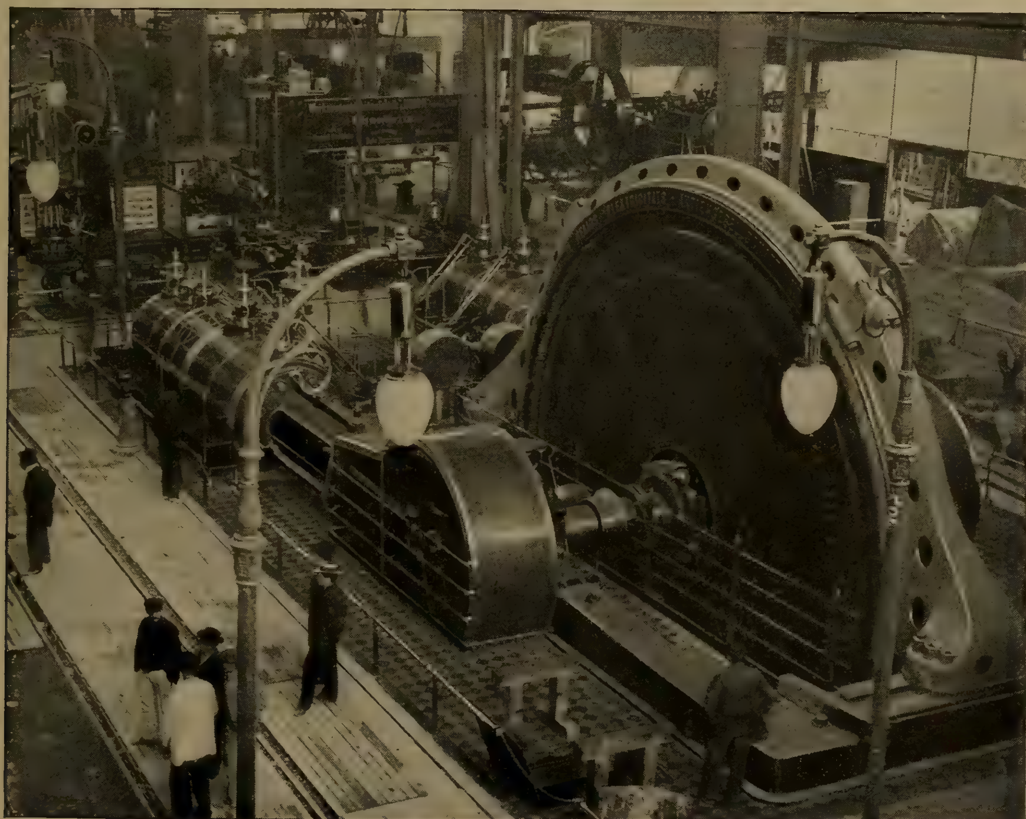


THREE-PHASE 300-KW GRAMME ALTERNATOR FOR BELT DRIVING



A 1000-KW THREE-PHASE ALTERNATOR BUILT BY THE COMPAGNIE INTERNATIONALE D'ÉLECTRICITÉ, LIÈGE

company's manufactures, and also of many others. The alternator of the Société Anonyme d'Electricité et Hydraulique, shown the page 84, is typical of the slow-speed type mentioned above. It will be seen from the illustration that the field coils and pole pieces are easily removed by taking out the bolts holding each piece, and the armature coils are easily rewound, if necessary, without taking the machine to pieces. The exciter is neatly built on the same shaft



A 3000-H. P. STEAM DYNAMO BUILT BY THE HELIOS ELEKTRICITÆTS-AKTIEN-GESELLSCHAFT, KÖLN, GERMANY

as the alternator, and this practice is generally carried out where alternators are so fixed. On the other hand, if the alternator is coupled to the end of the engine shaft, then the alternator shaft is extended, and the exciter is mounted on the overhanging portion, as shown in similar machines by the same makers, but more particularly by those made by the German firms. This latter arrangement has the additional advantage of allowing repairs to be more readily made to the armature of the exciter on account of the ease with which the spider frame on which the armature is mounted can be slipped off the main shaft.

It is difficult to reconcile the practice of one exciter to one alternator with the ideas of some British engineers, who prefer to "bank" separately driven exciters on to one switchboard, and so be able to use any exciter on any alternator. The alternators exhibited by the Compagnie de Fives Lille and the Liège Company (see page 86) were other instances of this type of machine.

The French designers in many cases have devoted their ingenuity to perfect a "compounding" of their alternators, and that shown by the Maison Breguet was typical of these ideas. The arrangement was made up of a three-phase generator, a three phase transformer, and an exciter with the field coils wound to take alternating currents. The armature is wound with two sets of coils of certain proportionate lengths,

A 3000-KW ALTERNATOR BUILT BY THE ALLGEMEINE ELEKTRICITÆTS-GESELLSCHAFT, BERLIN

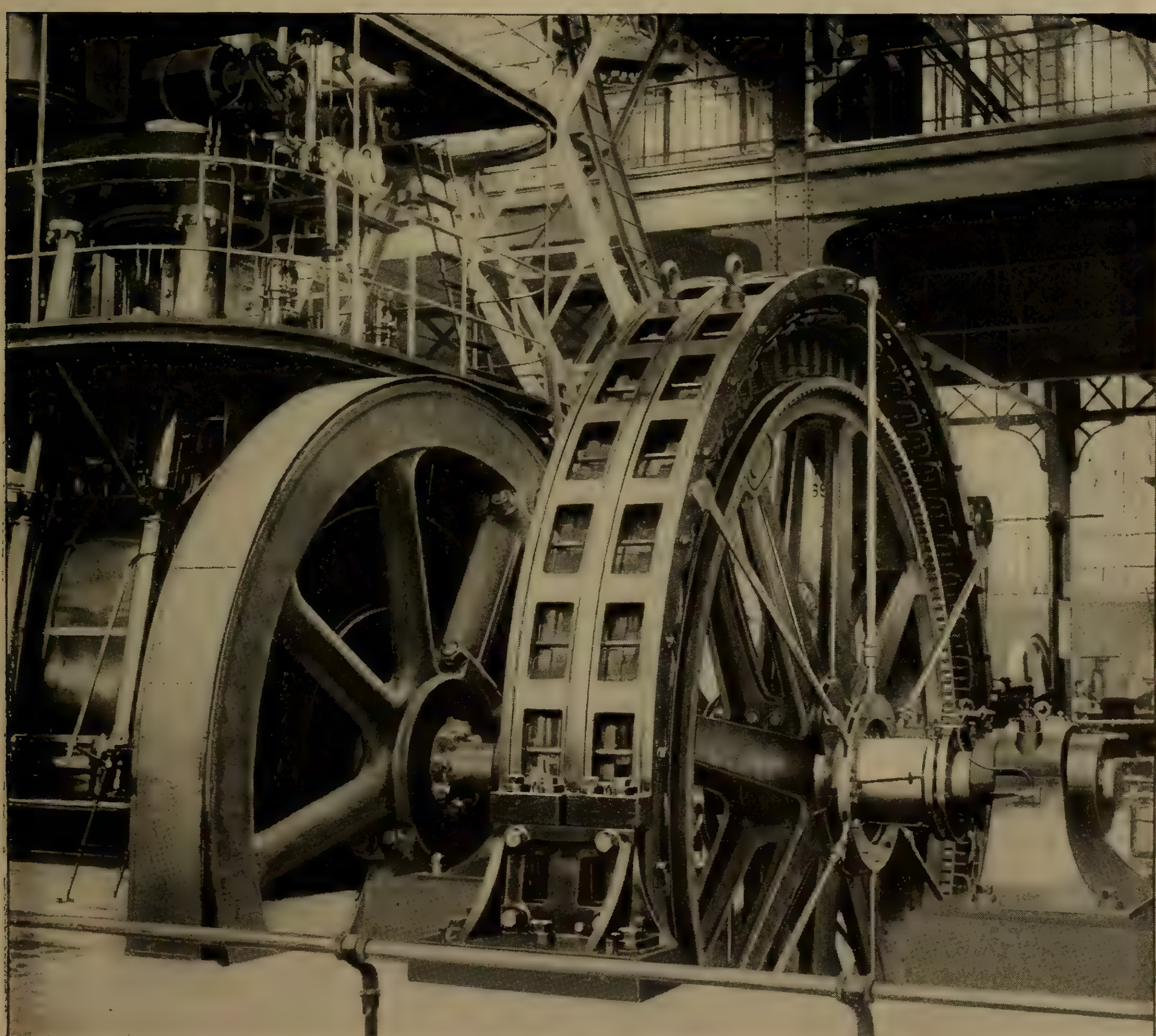
and at a specified speed the commutation of the armature current provides continuous current for the exciters of the alternators. It does not appear that this "compounding" has any material advantage beyond insuring a rise of pressure if the load be suddenly removed from the dynamo.

The German firms, as a rule, prefer vertical two or three-crank, slow-speed engines, but a notable exception to this is found in the case of the Helios Company, who showed the dynamo illustrated on page 87. It was coupled to a slow-speed horizontal engine, which is particularly interesting from the manner in which the manufacturers have turned out the machine, which reminds one of the conjurer's bottle from which one could, at will, produce any liquid, for the following combinations are possible in this machine:— Either single-phase alternating current at 6000, 3000 or 2000 volts up to 2000 KW; or single-phase alternating current at 2000 volts up to 1200 KW, simultaneously with three-phase alternating current at 2000 volts up to 1500 KW; or three-phase alternating current at 6000 volts up to 3000 KW. The extreme diameter of

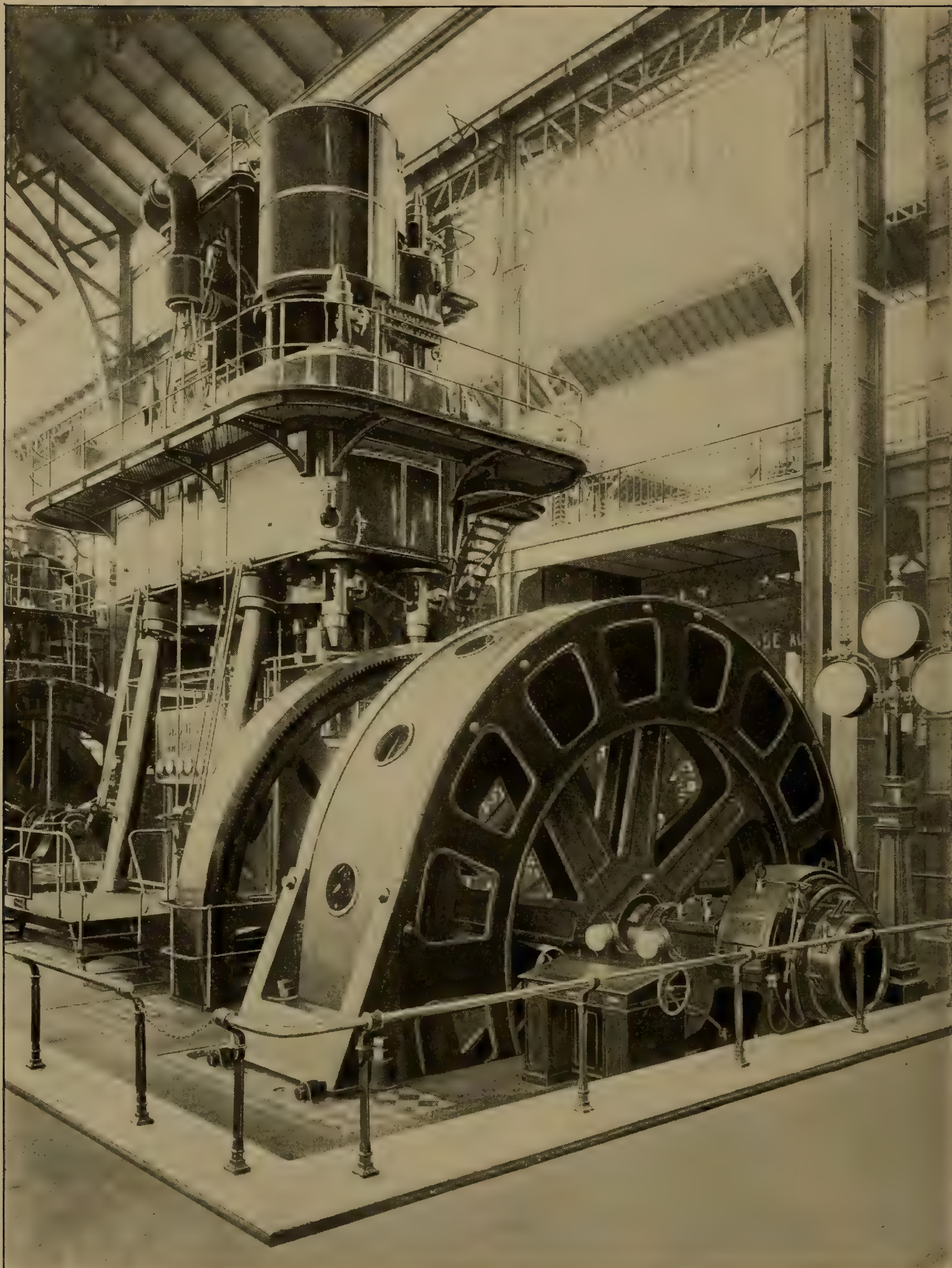
the armature is 31 feet; its weight is 50 tons; and the fly-wheel and field magnets, with their windings, weigh 76 tons.

The Schuckert Company's three-phase alternator (shown on this page) is rated at 900 KW at 5000 volts. This firm has adopted the plan of stiffening the armatures of their alternators by radial steel rods, which start out from, and are bolted to, a concentric ring clear of the shaft, and on the outer end are bolted to the outside edge of the armature casting.

Messrs. Siemens & Halske's 2000-KW alternator (page 90) generated at 2200 volts, and besides the heavy fly-wheel on which field magnets were mounted, a 40-ton fly-wheel was fitted on the same shaft, and was used for barring the engine round. The field magnet coils in this machine are ventilated by slots cut in the pole pieces. The armature is built up by suspending the coils and cores between two heavy rings, which are accurately turned on all sides. These rings rest on rollers fixed in the wheel-race, as shown on page 91, and by raising or lowering either or both of the rollers it is possible to adjust the position of the armature with respect to the field magnets, and on removing the brackets which hold the machine in position when running, the whole armature may be revolved for examination and repair. The desk in the cut on page 90 contained the resistances and resistance switches used in the regulation of the alternator field, and also formed a receptacle for the tools, log-books, and stationery of the workmen in charge of the plant. The Allgemeine



A 900-KW THREE-PHASE ALTERNATOR BUILT BY THE MESSRS. SCHUCKERT & CO., NURNBERG, GERMANY



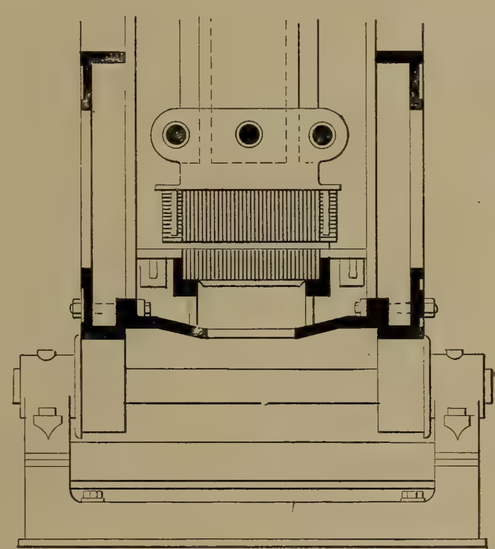
A 2000-KW THREE-PHASE ALTERNATOR BUILT BY MESSRS. SIEMENS & HALSKE, BERLIN, GERMANY

Elektricitäts-Gesellschaft showed a 3000 KW three phase alternator (page 88) coupled to an electric motor. The machine is one of a number being erected for the Berlin electricity supply station. The armature is 29 feet in diameter, and weighs 80 tons, and the field magnets, fly-wheel, and bed-plate together weigh 80 tons more. The practice of the Swiss firms varies as regards the class of engine used for driving the alternator, but the usual arrangement follows the French and Belgian ideas, excepting that triple-expansion engines are more frequently used than compound. The Brown-

Boveri Company's exhibit of an 1800-KW alternator (illustrated on page 93), generating at 6000 volts, showed a variation in the arrangement for stiffening the armature. In this case heavy cast-iron ribs start out from a ring accurately fitted on the plummer block, and this arrangement allows the whole of the armature, when the bolts holding it in position are removed, to be turned by means of a barring-gear in the slots cast on the outside of the armature casting. The Oerlikon alternator of 1300 KW is built on much the same lines as the Schuckert machine, without the radial stiffening rods. There were other alternators by Ganz & Co., of Budapesth; J. Rieter & Co., of Winterthur; Kolben, of Prague; and Lahmeyer, of Frankfort, all of which were good representative machines, very similar in design and workmanship to those already described.

The Westinghouse Company's exhibit in this line was of a most extensive nature. The company took advantage of the large power station at Moulineaux, to operate the Western Railway Company's Paris-Versailles line (about eleven miles), which is about four miles from the Exhibition, to transmit 5000-volt, three-phase current to a distributing station in the Exhibition, and it was there transformed either by induction motors directly connected with the high-pressure circuits and driving direct-coupled, continuous-current dynamos at 550 volts, or through a bank of static transformers to 340-volt, three-phase current, and then by low-pressure rotary converters to 550 volt continuous current. Both arrangements were used for driving the electric railway and moving platform, the former at times of heavy load, and the latter at times of light load. The direct-connected, high-pressure induction motor was started up by smaller converters by using the continuous-current dynamo as a motor, and as its size was rated at 850 H. P., the makers claimed it to be the largest induction motor yet made expressly for use on a 5000-volt circuit. It is shown on page 97.

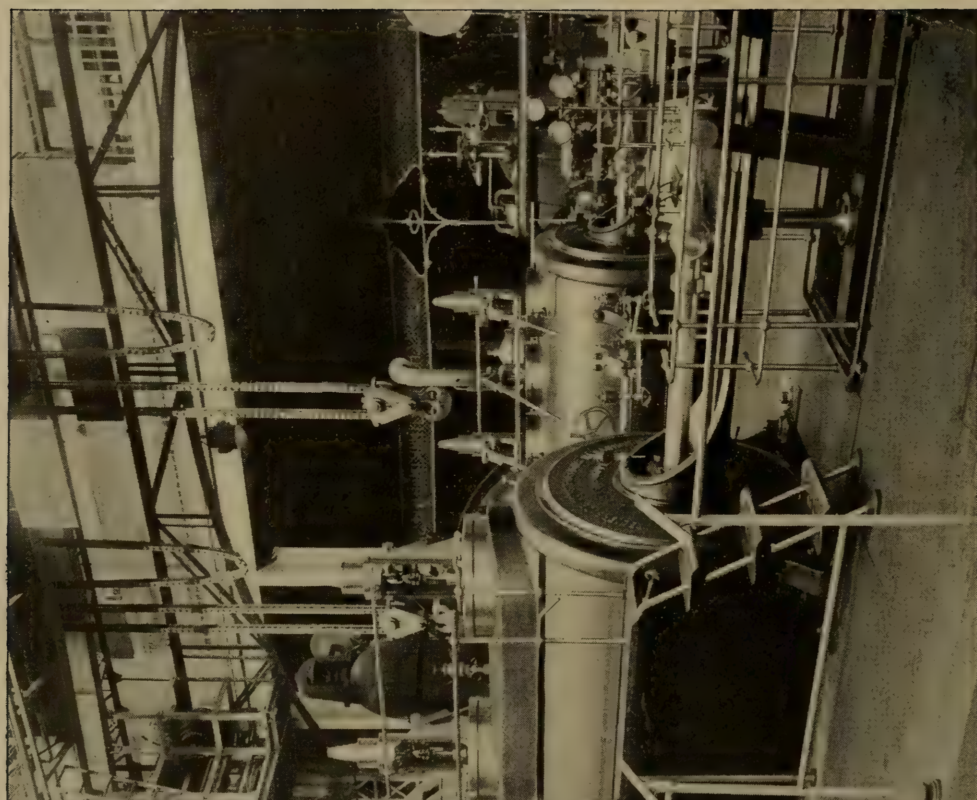
The continuous-current dynamos shown at the Exhibition offered little variety of design from the British practice. The sizes varied from the 1350-KW, Siemens Brothers & Co. steam-driven dynamo, shown on page 95, down to a 2-KW, direct-coupled oil engine and dynamo, shown by the Société Gramme. This latter was a compact little set, occupying about 33 inches by 16 inches floor space, and represented a convenient plant for small, isolated installations. The armatures in most of the machines are either slot or tunnel wound, though some makers still keep to the smooth surface winding with wooden distance pieces; but this is gradually going out



METHOD OF SUPPORTING SIEMENS & HALSKE ALTERNATOR ARMATURE

of favour with the increased size and the strain which the machines are called upon to stand. In France the old Gramme ring still finds favour, especially with the older manufacturers.

The Société Alsacienne showed a machine which collected on to the commutator fixed on the outside edge of the dynamo, and in this case the field magnets were bolted to the engine-bed, and the overhanging Gramme ring revolved outside them. The collecting gear was a huge, star-shaped spider, the brushes being carried on gun-metal rods, insulated from the frame. The Société de Laval showed one of their steam turbines coupled direct to two 200-KW ma-



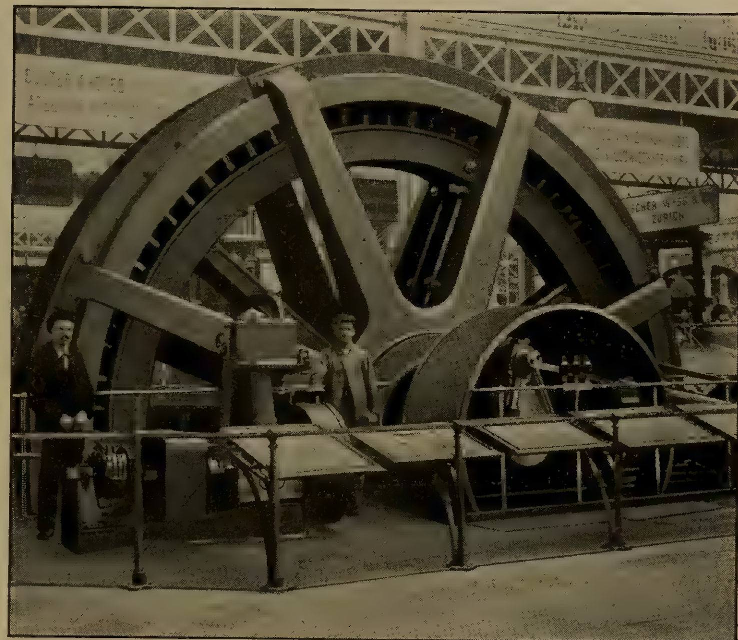
THREE-PHASE ALTERNATOR. 1200 KW, 2200 VOLTS. BUILT BY MESSRS. GANZ & CO., BUDAPESTH

chines, and a neat arrangement was made of the brush gear by connecting it to one quadrant, so that the brushes on each machine were moved backwards and forwards simultaneously.

Without giving sections of each particular make of continuous-current dynamo, it would be difficult to describe the arrangement of their construction, but it may be taken as a general principle, as before mentioned, that the slot and tunnel-wound armatures, with copper rods insulated with micanite, and each rod bent into its particular shape for connecting before fitting on to the machine, were the rule. The number of poles per machine varied from four to sixteen, and it would be a difficult matter to award the palm of superiority to any of the makers in this class of dynamo, more especially as it was evident that some of them had done yeoman service in the supply of energy to the Exhibition authorities. With few exceptions, carbon brushes were universally used. The exceptions were those firms who still use copper and gauze wire brushes, and in one machine copper gauze brushes with a carbon tip placed at the end of each brush were used to prevent sparking.

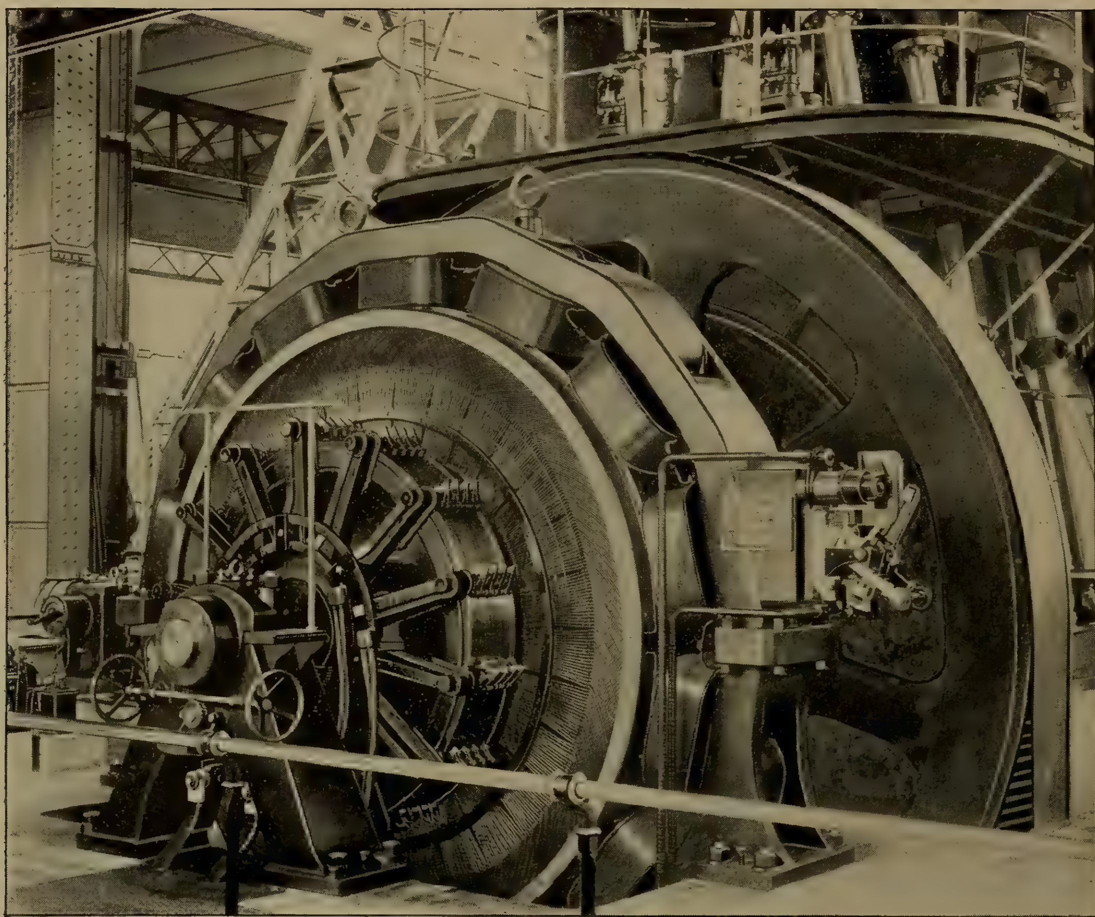
"Facilities for examination and repair" is one of the sentences generally inserted in British specifications for electrical machinery, and on this point there is a divergence of practice on the Continent. French and Belgian makers adhere to the arrangement of a couple of strong eyes bolted on to the tops of the alternators, and lift off the top part of the machine by an overhead crane. How the bottom half is examined and repaired is not stated, unless the whole fly-wheel is lifted bodily away from the lower half of the armature.

Before leaving the subject of generators, a few words may be said of central-station practice on the Continent. None of the machines exhibited was of less than 300 KW for even continuous-current work, excepting, of course, belt-driven dynamos, and from conversations with several of the exhibitors it appeared to be evidently not the practice, even in small towns on the Continent, to put down machines for public supply of less capacity than this. There seems to be no doubt in the minds either of the municipal authorities or the supply companies that electricity supplied on reasonable lines will pay its way and leave something over to satisfy interest and depreciation on the outlay. Small towns, in which such size of plant would not prove remunerative, are supplied in bulk from a neighbour, it may be twenty or thirty miles distant. In Great Britain this practice is only just being recognised, and it is to be hoped that sooner or later,—the sooner the better,—the smaller towns will be encouraged to group together, to be supplied from one central works in areas of, say, fifteen miles radius.



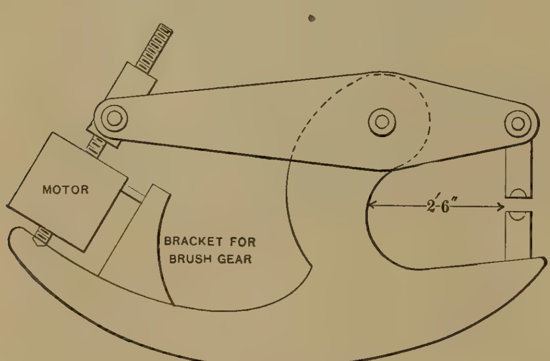
AN 1800-KW ALTERNATOR, BUILT BY MESSRS. BROWN, BOVERI & CO., BADEN, SWITZERLAND

Turning to the application of the energy at the Exhibition, one was at once confronted with an enormous number of interesting designs. Ventilating fans, centrifugal and other pumps,



AN 850-KW CONTINUOUS-CURRENT DYNAMO BUILT BY MESSRS. SCHUCKERT & CO., NURNBERG, GERMANY

cranes, and machine tools of all types and sizes, tramways, railways, in fact, every appliance used in engineering workshops and in daily life, was shown driven by electric motors. A three-phase, alternating-current motor and its starting and regulating switches lend themselves admirably to all the above-mentioned applications, more particularly where the workman who operates the switch is untrained in electrical work.



AN ELECTRIC RIVETER

The switches, as a rule, were solidly made, well insulated, generally with cast iron handles, and the electrical contacts all covered and securely fastened to prevent their being touched. The motors were well braced up, and provided with suitable glands for the connecting cables, and presented only an oil cup and pulley as evidence that there was anything of a rotating nature inside. Provision was extensively made for radiation, by heavy cast-iron ribs, giving the motor the appearance in some cases of a rope pulley, and in others of a gridiron on each face of the motor case.

In many cases the motor was provided with a small stand containing an ammeter and regulation switch, with points marked off to enable the workman to know what current he should use for certain work; in all matters of this kind the workman was presumed to be entirely ignorant of electricity, and was

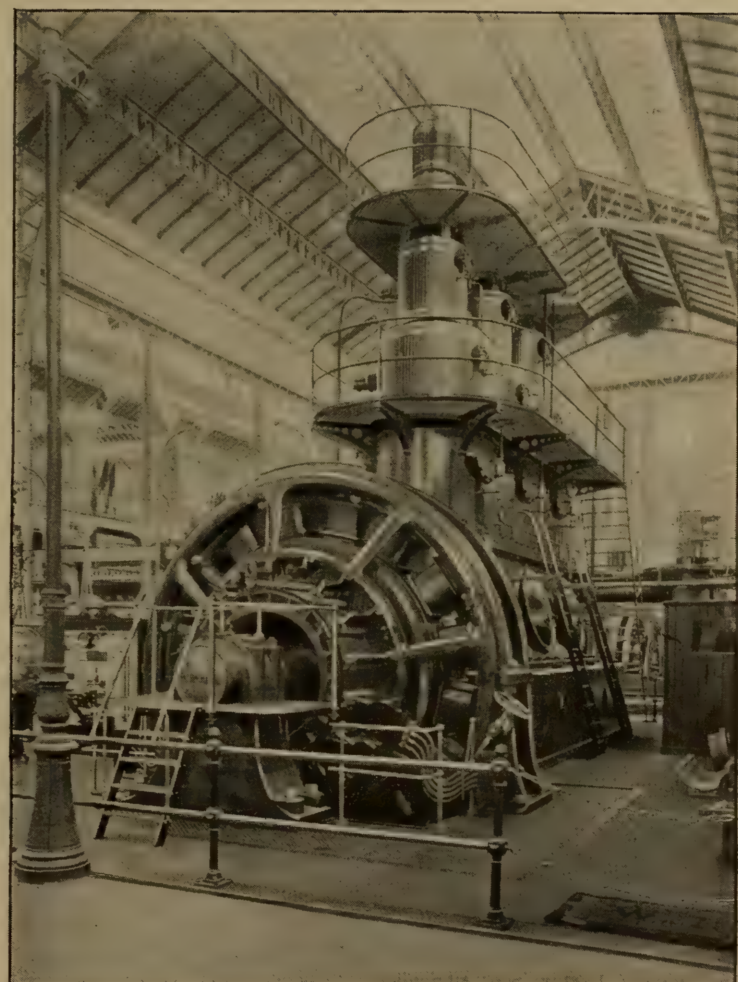
supposed only to know that if he turned the handle, the motor would do the rest. In many instances the stands for the heavy castings supporting machine tools were utilised to contain the motor. Motors for attaching to silk weaving and winding machines were, of course, a Continental specialty.

Electric riveters and electrically-driven barring gear for heavy fly-wheels were other instances of the application of electric power. The electric riveter, of which a sketch is given on page 94, was operated by a 2-H. P. motor, running at 1200 revolutions per minute, and was provided with an automatic switch, conveniently situated on a pillar close to the workman, which cut off the current as soon as the rivet was properly fixed. The machine was capable of closing 120 rivets per hour.

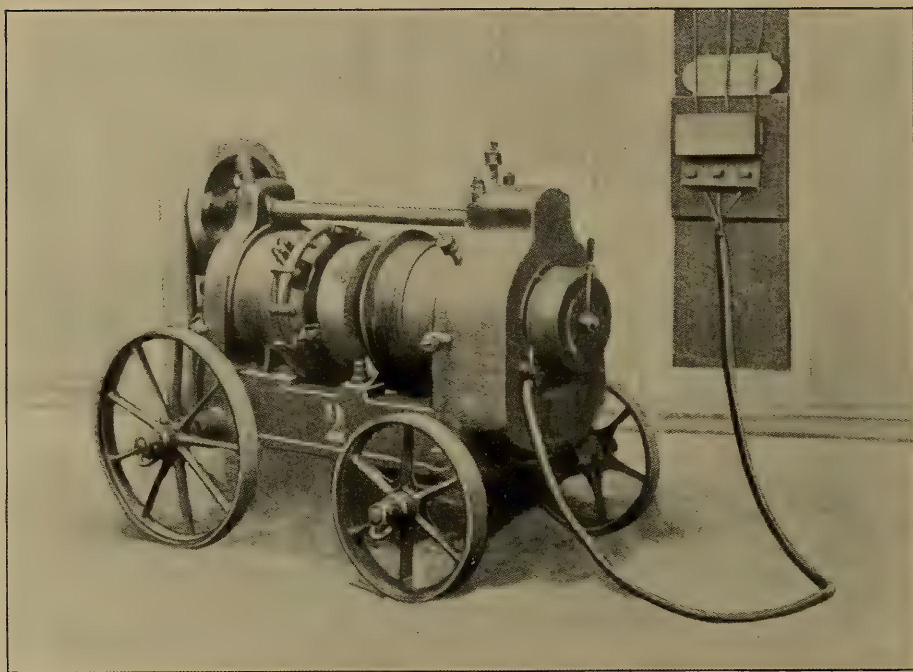
These, however, were only a few cases of application of electricity to motive power. There were many others, such as ploughing and threshing by electric power, log saws and band saws driven direct by electric motors, light, portable winches for wharf work, chain-making machinery all kinds of dairy machinery, —in fact, there appeared to be no trade where motive power is required which had not been taken up and conquered by Continental manufacturers.

The inclined stairways and elevators, of which there were a large number in operation all over the Exhibition, are likely to become better known. The average power required to drive a 42-foot stairway was stated to be 6 H. P., and this size was capable of raising eighteen or twenty persons to a height of about 20 feet, as against 11 or 12 H. P. required for a direct vertical lift. The moving platform was one of the novelties among the exhibits. It has been described in so many places that it will suffice to say here that the power required to start and run its two and one-half miles of length, weighing 2200 tons when empty, and 3300 tons when fully loaded with 40,000 persons, varied from 90 to 200 KW at a speed of three miles an hour on the slow platform and six miles an hour on the fast platform.

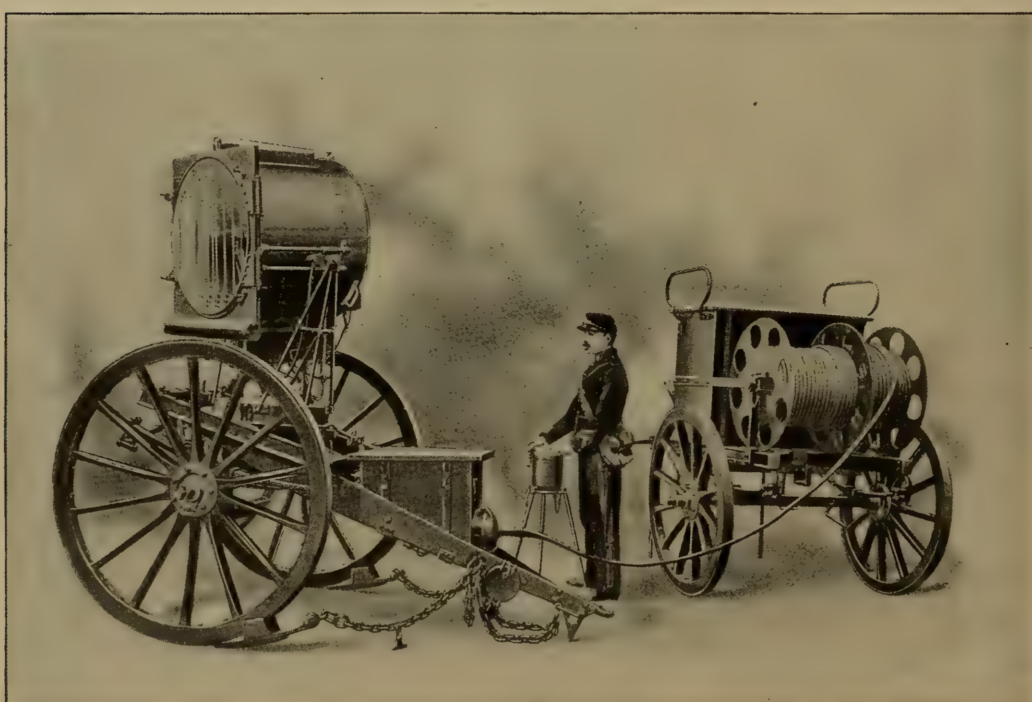
Mining, shunting, and heavy electric railway locomotives were also extensively exhibited. There was no particular novelty in any of these, but mention might be made of the electric locomotive built as an experiment for the Paris, Lyons & Mediterranean Railway Company. The motive power for this was furnished by a battery of accumulators carried on a tender. The control of search-lights from a distance was a



A 1350-KW CONTINUOUS-CURRENT DYNAMO BUILT BY MESSRS. SIEMENS, BROS. & CO., LTD., LONDON. THE GENERATOR IS CONNECTED DIRECT TO A WILLANS ENGINE



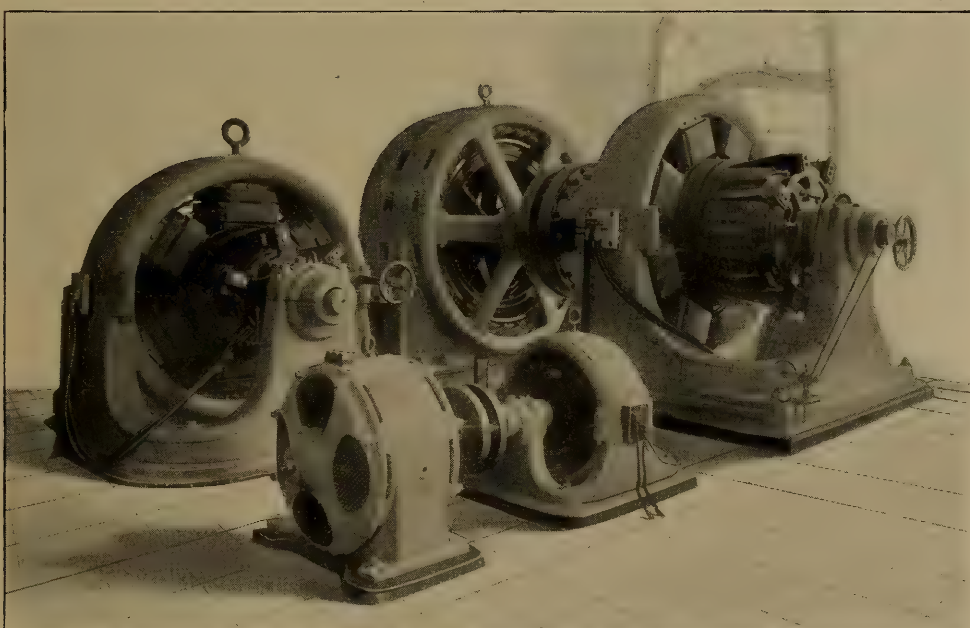
PORTABLE WINCH DRIVEN BY A 12-H. P. ELECTRIC MOTOR. MADE BY MESSRS. BROWN, BOVERI & CO., BADEN, SWITZERLAND. USED SINCE 1896 AT THE HAVRE DOCKS



A PORTABLE ELECTRIC PROJECTOR CONTROLLED FROM A DISTANCE

matter which had been taken up by many of the exhibitors, and the arrangement was generally after the fashion shown on page 96. A military cart, somewhat like a gun-carriage and its limber, was run to the point to which it was desired to fix the search-light; the limber, with search-light attached, was then detached, and the carriage was run back 400 or 500 yards, or more, as the case may be, leaving a coil of three or four-cored armoured cable on the way. In the base of the projector two motors were fixed, one for giving the vertical and the other for the horizontal movements, and also a cutting-out device when the lamp was at its full extent, in each direction. In cases where the supply cannot be obtained elsewhere, the carriage is provided with an oil or steam engine and dynamo, and a pillar containing the regulating switches which control the lamp and its motors. The arrangement seems compact, and likely to be of considerable use in military work.

Transformers for high-pressure work were shown on all sides, and, as a rule, were enclosed in solid, well-made, cast-iron cases, with plenty of allowance for radiation, examination, and repair. In switchboard arrangements, the practice appears to be, in alternating currents, to provide a stand containing the instruments for each machine, with levers geared to switches fixed below the floor, and in all cases ingenuity was displayed in the arrangements for interlocking the exciting circuit switches with the high-pressure, alternating-current switches. The switches employed for use on three-phase circuits on some of the French and Belgian machines presented little novelty in design; generally a plain, quick-break switch was used. The Helios Company uses three arms mounted at three angles on a spindle, the contacts being made or broken one after the other, and on breaking a heavy current the arc is extinguished by compressed air, blown through ebonite tubes.



THE 850-H. P. INDUCTION MOTOR IN THE WESTINGHOUSE COMPANY'S PAVILION

The Schuckert switch is founded on the well-known principle that an alternating arc is difficult to maintain through a space of a few millimetres between balls or rollers, and consists of a series of metal rollers, mounted on flat springs, so that each roller is free to turn on its own axis, and as the switch is operated, the cams which are shown in the centre of the switch on page 99 press the springs together, and so make a contact from roller to roller, and finally complete the

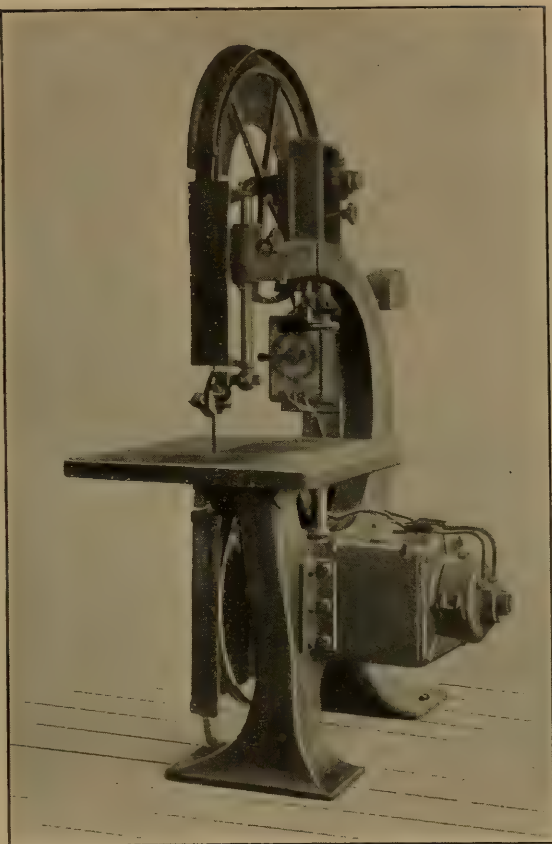
ONE OF THE ELECTRIC CABLE EXHIBITS OF THE FELTEN & GUILLEAUME CARLSWERK, MULHEIM-ON-RHINE, GERMANY

circuit on each side through solid gun-metal switch arms. The operation of the switch when putting two machines in parallel is as follows:—The centre arm bracket makes contact first on the third wire of the three phases, and as soon as synchronism is established by the aid of the ordinary apparatus of a synchronising transformer and incandescent lamps, the two sets of rollers are brought into circuit by pressing the cams, and as the rollers and their springs have a certain resistance, due to imperfect contact and their number, any current which may flow to completely establish synchronism is allowed to pass for the fraction of a second which it takes to complete the circuit through the proper and low-conductivity switch arms. The operation of disconnecting a machine is in the reverse direction, and as the rollers are free to revolve, they not only clean themselves, but present new surfaces each time that the switch is operated. It is quite possible to break a 5000-volt, three-phase circuit when a current of as much as fifty ampères is flowing, without any detriment to the switch.

Electrically-driven motor cars naturally found a place in the Exhibition. On page 100 are shown the latest types of carriage and parcels delivery van now in use in Paris, owned by the Compagnie Française de Voitures Electromobiles. These carriages, of which about 150 are in use in Paris alone, are competing very successfully with petroleum-driven or horse carriages, in spite of the fact that the price for "power" is

3½d. per Board of Trade unit, and that the batteries will carry a charge sufficient only for from 45 to 70 kilomètres, according to the speed at which the carriage is driven, and this is variable from walking pace to sixteen miles an hour. The regulation of the acumulators is done by a series-parallel controller, putting the cells into series or parallel, or series-parallel, according to the speed at which it is desired to drive the carriage. The parcels van is capable of taking 25 cwt. of goods, as well as two persons, and, of course, runs at a slower speed, generally eight miles an hour. The company is trying all sorts of cells under varying conditions of service, and it has not yet decided on the best cell for either high-speed carriage or low-speed parcels delivery work.

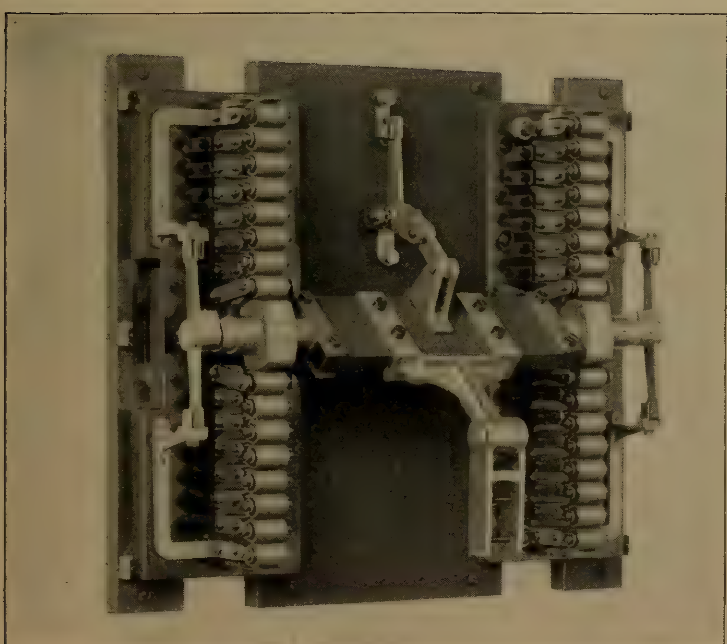
This mention of electric accumulators reminds one that no description of electrical apparatus is complete without some mention of them, but it is to be regretted that there were not many exhibits of this nature, and, except as regards size, nothing new. A cell exhibited by the Accumulatoren-Fabrik Aktiengesellschaft, of Berlin, stated to give 50,000 ampère-hours in ten hours, or 25,000 ampère-hours in one hour, and occupying a cubic space of 6 feet each way, was a distinct reminder of the extent to which electric storage batteries are being used in Germany.



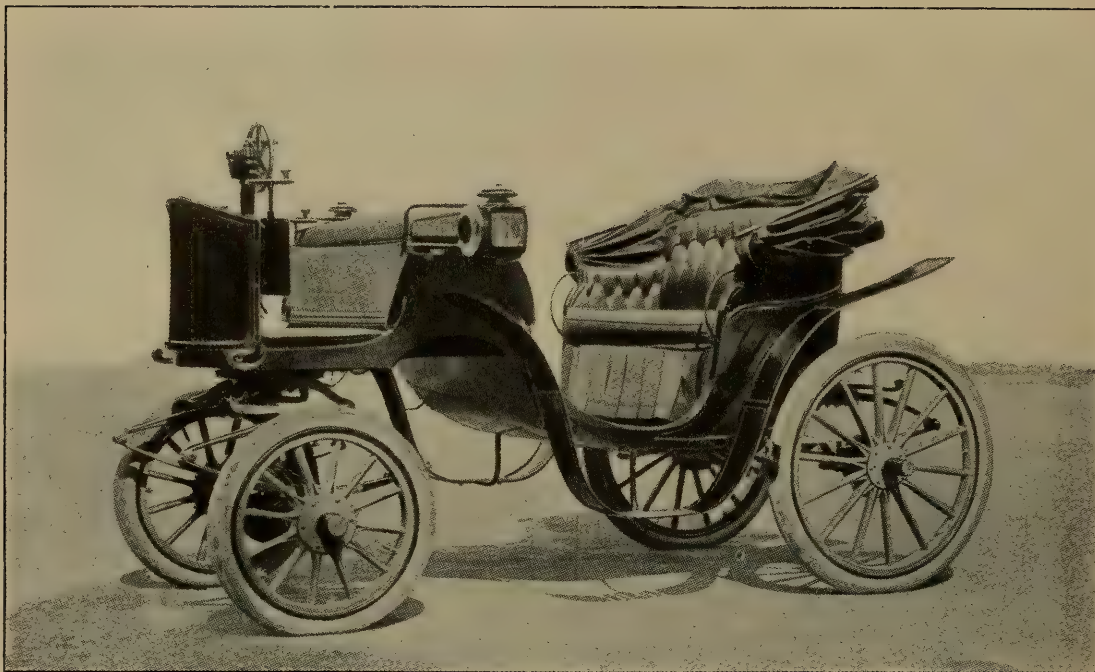
AN ELECTRICALLY DRIVEN BAND SAW, MADE BY THE VEREINIGTE ELEKTRICITÆTS-AKTIENGESELLSCHAFT, VIENNA

Electric cooking and heating apparatus does not appear to have made greater progress than in Great Britain. One small exhibit in this line contained a saucepan with a notice that the article shown "was not to be confounded with bad German imitations." Whether this frightened this progressive nation is not recorded, but the fact remains that the writer did not see a single "German imitation" in the Exhibition.

The exhibits in cables and street-junction boxes did not show any great variety. Rubber appeared to be the prevailing insula-



HIGH-TENSION, THREE-PHASE SWITCH. MADE BY THE BRITISH SCHUCKERT ELECTRIC CO., LTD., LONDON



ELECTRIC CARRIAGE USED BY THE COMPAGNIE FRANÇAISE DE VOITURES ELECTROMOBILES. MAXIMUM SPEED, 16 MILES AN HOUR. DISTANCE AT 8 MILES AN HOUR, ABOUT 37 MILES

AN ELECTRIC PARCELS DELIVERY VAN USED BY THE COMPAGNIE FRANÇAISE DE VOITURES ELECTROMOBILES

tor, and several firms showed samples of rubber-covered cable made up to withstand 25,000-volt, three phase alternating currents. Other cables shown were of the resinous and other compound types well known in Great Britain.

From figures which were displayed at the Exhibition and data taken from *Lighting* for the same period, a comparison has been made in the table below of the position of electricity supply

	LONDON	PARIS
Capital invested	£6,955,873	£4,320,000
Kilowatts installed	57,666	23,515
Capital invested per KW	£120.10	£184
Equivalent of arcs, motors, and incandescent lamps expressed in 8 c. p. lamps	2,648,176	1,202,981
Units sold 1899	46,347,973	21,097,223
Units per 8 c. p. lamp	17.35	18
Revenue from electricity supply	£915,159	£737,671
Revenue per unit	4.73d.	8 7d.
Price of gas per 1000 cf.	2/5d. to 3/5d.	Aprx. 7/1d.

in Paris and London on December 31, 1899, and the figures of revenue relating to the twelve months which ended on that day.

In concluding this brief résumé, it is not too much to say that the French nation is to be congratulated on having brought together so many manufacturers and their apparatus, in a manner which must add to the prosperity of the electrical engineering industry. The progress which has been made by Continental manufacturers, and the courage with which they have attacked and solved many of the problems connected with the generation and application of electricity, show that Great Britain has a great deal yet to do, more than is generally known, to make up the leeway into which she has fallen in this respect, and it is hoped that the lessons and experience of our Continental brethren in the electrical industry may bear fruit to the mutual advantage of themselves and the British nation.

INDUSTRIAL COMBINATIONS IN THE UNITED STATES

LABOUR, INTELLIGENCE, AND MONEY

By Charles R. Flint

MR. CHARLES R. FLINT is so well known, even beyond the confines of the United States, as one of the world's most progressive merchants, that it seems almost unnecessary to specially introduce him to the reading public. But since, of late, he has been variously dubbed the father of "trusts" and the head organiser of industrial combinations, it may not be amiss to point out that what he himself has to say on these subjects ought to have the value of high authority. Indeed, Mr. Flint has studied them most carefully, and his presentation of them recently in a speech delivered at a banquet of the Illinois Manufacturers' Association at Chicago, was an admirable exposition of what "trusts" are and of the benefits that they have brought about. Through his co-operation, his remarks on that occasion have been made available, in revised form, for publication here.—THE EDITOR.

A combination of labour is a trades union; a combination of intelligence, a university; a combination of money, a bank; an industrial combination is a combination of labour, intelligence, and money.

There seems to be much confusion in the minds of the people as to the difference between a trust and an industrial company, due to the fact that those who talk most about them are not yet well informed, either as to their organisation or operation. A trust was a syndicate of men who held stock certificates of several corporations and issued trust certificates therefor. Now, industrial interests are represented by shares of stock in regularly organised companies. Although strenuous efforts were made to develop the trust system, it was found to be imperfect. It was adopted when industrial combinations were in their infancy. I have always been opposed to the trust system of organisation. They were not required to have any by-laws or keep any official minutes of their proceedings, or to make any official reports. In general, it might be said that they possessed great power without sufficient accountability. The Supreme Court of the State of New York declared them illegal, and every lawyer who is informed in regard to industrial organisations will tell you that that decision has been accepted as final throughout the United States. But the word "trust" has since been applied to great industrial corporations, and as the word represents all that is best in human character, I see no reason why the word "trust" should not be adopted as a short name for industrial combinations, and may every officer and wage-earner in every "trust" realise that the shares of stock are widely distributed among widows, orphans and others dependent on its dividends for support, and live up to the true meaning of the word.

In studying the evolution of industrial life, we find that combination is coincident with civilisation. Savages have little power to combine, because combination depends on trust in our fellowman, and in primitive life it is fear that rules. One of the first steps in indus-

trial evolution was to subdivide production into trades. Each did what he could do best, settling accounts by an exchange of products. Later, those engaged in the same trade formed partnerships, then corporations, and finally consolidations of corporations.

Against this march of industrial progress there has always been opposition. There have always been those who, appealing to special interests, to the unsuccessful, the discontented, and the misinformed, have endeavoured to obtain political favour by opposing progress, by endeavouring to prevent the natural, and mutually beneficial, cooperation between capital and labour.

Centralised manufacture permits the highest development of special machinery and processes. The factory running full time, on large volume, reduces the percentage of overhead charges. Direct sales on a large scale minimise the cost of distribution. Centralisation of manufacture and distribution reduce aggregate stocks, and therefore save shop wear, storage, insurance, and interest. Consolidated management results in fixing the standards of quality, the best standards being adopted; in avoiding waste and financial embarrassment through overproduction; in less loss by bad debts through comparisons of credit, and in securing the advantages of comparative accounting and comparative administration.

Industrial evolution, which is as inevitable and as unalterable as the law of gravitation, has attained its, as yet, highest development in the United States. Every unprejudiced man must recognise its advantages, and that it is because of them that that country is taking so important a position in the world's markets, increasing its national wealth, furthering the welfare, and increasing the prosperity, of its people.

The great problems of the economics of production have been solved. What interests us most to-day is the question whether the advantages of the prosperity secured are equitably divided among the contributors to it:—(1) Capital; (2) Superintendence; and (3) Labour.

(1) The share to capital takes the form either of interest or dividends. Now, we find that the rate of interest paid to those furnishing money to industrial enterprises is decreasing. Fifty years ago the average rate throughout the United States was 8 per cent. per annum. Now it is less than 5 per cent. This general rule can be laid down, that the greater the confidence, the higher and more perfect the industrial organisation, the lower the rate of interest. During the year 1896 the stability of American currency and the fundamental conditions of American industrial development were regarded by many with doubt; and money loaned as high as 20 per cent. The investor is ever willing to take lower interest in exchange for greater security and for a steadier and less precarious demand for his funds,—and so that form of industrial organisation which furthers careful financing, opens wider markets, and guarantees greater confidence and stability, is directly in the interest of capital, although the rate of return on capital is thereby steadily reduced.

The dividends received by shareholders are larger than the interest rates, because the risk is greater, and, moreover, being partners and shareholders, they are entitled to a larger share in the advantages of combination. Still, it is doubtful if the aggregate of dividends is as large as the aggregate of interest. Moreover, dividends are never absolutely certain, and they are never paid until labour and superintendence have first had their share.

(2) Now, what is the position of the man of superior intelligence, for superintendence stands midway between capital and labour? Highly developed organisations, resulting in enormous volume of business, have increased the necessity for intelligence, and as the supply of brains is not equal to the demand, the price of brains is high. The turning over of individual businesses to combinations has caused the retirement of old men to the advisory board for judgment and has made way for young men for action. You ask, "What chances have our young men?" While you are asking the

question, those of ability and energy have already started on a career of successful industry. If the student will leave his books and the orator the stump and go to our factories, to our great farms, to our mines, to our lines of railway, they will find ten times as many men receiving over $3,000 per annum as there were thirty years ago.

Mr. Schwab, of Pittsburgh, is a type. He started as a stake driver of an engineering corps; to-day, though under forty years of age, he is president of the largest iron company in the world, and I can point out a hundred successful men to-day where you could not have named ten under old conditions.

But it is said, they are dependent. Dependence upon one another is, however, a condition of civilisation. The very word civilisation implies community life, and community life means mutual dependence. Complete independence is found only in the wigwam of the Indian. There the young man builds his own house, makes his own clothes, gets his own meat, and keeps his bank account, if he has any, in his pocket. The best opportunity he has for distinction is in showing superior prowess in hunting, or superior strength in paddling his own canoe. In civilised life, interdependence is more profitable than independence. But let us not spend more time in considering who will take care of these young men of superior intelligence; they will take care of themselves.

(3) Let us now consider the interests of the workingman in this economic evolution which has produced the perfect machinery and giant factories, supported by great aggregates of capital represented by shares which enable all to become investors It is a fundamental fact that the man of superior ability cannot accumulate for himself without giving to the wage-earners an opportunity to earn the larger share, and it is always an increasing share.

The tendency is to-day to a minimum of profits and to a maximum of wages. When profits become abnormal, they invite competition, and are immediately reduced; in that case, the consumer solely is benefited. If they are not sufficiently abnormal to invite competition, then labour demands a larger share of the profit, in the form of increased wages, and it is either voluntarily or necessarily agreed to, in which case the body of wage-earners reaps the advantage. And, inasmuch as the body of wage-earners is the great body of the community, it necessarily reaps the advantage in any case. Employees know almost as promptly as do the employers whether a mill is earning an extravagant profit. If it be, they at once demand their share, and the employer must, and inevitably does, succumb. It is thus that wages always tend to a maximum, and profits to a minimum.

The maintenance of the high standard of wages now paid in the United States is absolutely dependent upon our realising the advantages which come through superior organisation. We are to-day shipping manufactured goods to countries where the rates of wages average 40 per cent. less than our wage-earners are receiving. Of our exports of manufactured goods, 80 per cent. are produced by large industrial corporations. Articles of manufacture which we do not produce through consolidations are being almost entirely supplied to the neutral markets by the cheap-labour countries, — Germany, Belgium, and Great Britain. The centralisation of manufacture and consequent use of special machinery have emancipated the slave,—have raised the American workman to the position of overseer, not of pauper labour, but of its productive equivalent, machinery. And he is receiving, and is entitled to, the wages of superintendence.

Now, the intelligent labour leaders understand this perfectly. It was my pleasure to entertain at my home some of the best known of these. Speaking of labour conditions, I asked one of them to define the difference between his organisation and that of the professional agitators. He replied:—"We hope to bring about by evolution what they claim should be accomplished by revolution." They said that they "welcomed new machinery, because it

did the work which had heretofore degraded labour."

The wage-earners of the United States are to-day enjoying a higher standard of living and a larger measure of well-being than wage-earners have ever enjoyed in the history of the world. They are the real money power. The railroad managers have rails and rolling stock; the miner has mines; the manufacturer has bricks, mortar, and machinery, and most of them have debts, and many are mortgaged to the banks for savings; but the wage-earners in the United States have on deposit in cash in the savings banks, subject to call, two thousand five hundred millions of dollars.

Thus through co-operation and combination every interest is being benefited, but labour most of all. As wage-earners become more intelligent, as they become overseers of machinery, they better understand these conditions. They have the intelligence to recognise that their greatest comfort and happiness is in furthering the industry of which they are a part. To-day one of the great advantages that the United States has over Europe is that its labourers are the more intelligent, are the healthier and happier. The European wage-earner, instead of welcoming labour-saving machinery, as workingmen in the United States have done, has tried persistently to retard its general use, and the result has been that wages have been lower in Europe. The American workman has received more because he has produced more, and this is the great reason why, notwithstanding our high wages, we are so rapidly extending our trade with foreign markets. The best factory inevitably gets the most work. There is a continued struggle for existence between good factories and poor factories, and the good factory invariably wins.

The law of consolidation of capital and division of labour holds as good in the field of distribution as in that of production. It is inevitable, and it is profitable. The department stores and the mail-order stores sell for 10 per cent. instead of 30 per cent. profit, and the consumer thus saves 20 per cent. The profit obtained by the distributer of staples, on the way from the farmer to the consumer, is less than one-quarter what it was thirty years ago. The farmer secures a wider market, the consumer gets his staples just so much more cheaply, and the enterprising middleman avails himself of improved banking and transportation facilities to do a larger business. This is why he has adopted as his motto, "Quick sales and small profits."

The real benefits of "capitalistic production," as compared with production on a small scale, are twofold. The first and greatest benefit of industrial combinations goes to the whole body of the community as consumers, through reduction in prices. The next benefit, and that next most largely distributed, goes, as I have shown, to the workers through increase of wages, and thus it happens that the workingman gains simultaneously in two ways. He gets more money for his work and more goods for his money.

Having reviewed the position of our great consolidated corporations as the results of an economic evolution, something should be said with regard to their capitalisation. In general there has been much greater conservatism in the capitalisation of industrials than there was in the original capitalisation of railroads. Our railroads were built principally for the amount of the bond issues, and the stock represented the capitalised hopes of the projectors. The issues of industrial bonds have been considerably below the actual value of the tangible assets, and industrial stock issues have generally been based on actual earning capacity. Still it is undoubted that there has been more than one instance of marked over-capitalisation of industrials, and no proper legislative measure to remedy this wrong or prevent its recurrence should be neglected.

Fortunately, the evil caused by careless investing and unwise capitalisation tends to correct itself by natural laws. Investors, confused by the few inflated industrials which were put out simul-

taneously with the sound ones, are afraid to buy, and the organisers, unable to sell their securities, now realise that sound capitalisation is the best policy.

In organising industrial companies, preferred stock, which is intended for an investment security, should not be issued in excess of tangible assets, except in special cases, where there is a very large earning capacity, protected by very valuable patents or trademarks.

Verified earnings and regular dividends will establish confidence, and the prices of the shares in the well-organised and well-managed industrials will advance as did the stocks of railroad companies which were originally issued for good-will. In reviewing the evolution of industrial combinations, I have taken a general and comprehensive view. In this evolution, as in all human affairs, there are imperfections and abuses for which it is our duty to find remedies. The man of narrow view to whom the imperfections are pointed out loses sight of the great benefits. He sees a dead tree in the landscape instead of looking all around the horizon.

While believing in great organisations; while knowing that they are a necessity in order that this country should become a great power in the economic world and thereby continue the prosperity of the wage-earners of the land, I do not believe in large aggregations of wealth in the hands of individuals unfitted to wisely administer them.

Wealth is a serious trust, and when left to those who lack experience in the use of it, is often a curse instead of a blessing. Money does us good only as we part with it, and there could be no great gifts without great fortunes. After providing a reasonable competency for the family, in my opinion the greatest satisfaction that can be obtained with money is to build up educational institutions, to facilitate aspiring young men to help themselves. Fortunately, under corporate ownership this can be done without liquidating or contracting great business organisations whose influence is so far-reaching that they may properly be called great business universities, and in justice to the wage-earners and managers who have assisted in building them up, and to the investors who are dependent on their dividends for support, such organisations should be sustained and improved.

One of the features of our industrial situation is that many of the men who have built up these great organisations are retiring. Those men who have blazed the way in this new and rapidly developing country have been the ablest industrial leaders the world has ever known, such men as Carnegie and Huntington, Rockefeller and Field, Armour and Vanderbilt,—the thinkers, the doers, the organisers,—men whose creations are the great landmarks in American industrial history.

It is fortunate that we have had such leaders. They did their work with the aggressive force that comes of natural energy and temperate living, and with the judgment that comes of experience. They have understood and have been in sympathy with the people because they have been of the people, and the example of those men, rising from the ranks, gives impulse, encouragement and high aspirations to every working man in the land.

They made their fortunes by reducing the percentage of profits and increasing the volume of business; by reducing the rate of freight on a barrel of flour to the Atlantic from $3 to 45 cents; by reducing the price of steel from $100 per ton to $20; by improving the quality and reducing the price of provisions and of by-products, while paying a higher price to the farmer for the animal; by reducing the price of oil from 30 cents to 10 cents; by reducing the price of cotton cloth from 20 cents to 5 cents. They realised that in order to make their combinations a grand success, they must increase consumption by reducing prices. Thus they not only helped to develop a great home trade, but enabled us to open the door of foreign markets, which has resulted in the enormous trade balance in our favour, on which American prosperity so largely depends.

The industrials to-day are owned by

the many. While economic evolution is centralising production in large corporations, decentralisation of ownership goes on simultaneously through the rapid distribution of shares. There are many hundred times more partners in manufacture, mining and railways than there were thirty years ago, and the number is rapidly increasing. Women rarely had an opportunity of obtaining an interest in business organisations, but now they are large shareholders of corporations, and as such they have the full right of suffrage.

Under the old conditions of private ownership, the control of many of our industrial enterprises would have been inherited by one individual or family. Now the control is subject to the rule of the majority. It is seldom, and fortunately so, as preventing great aggregations of wealth in the hands of individuals or families, that the heirs of the industrial giants have the capacity to succeed to the direction of gigantic enterprises. Many inheritors of great fortunes, enervated by ease and luxury, prefer a life of indolence, or to chase the will-o'-the-wisps of society; others prefer to devote their time to literature or art; others to enter upon scientific pursuits. Under the old conditions they would have inherited the control of industries, but under the present conditions of industrial consolidations the majority of the stockholders,—for, generally speaking, the numerical majority is also the majority in interest,—elect as officers aspiring young men who, through years of application to a particular industry, have proved their ability and judgment to assume the responsibilities of leadership, and owing to the higher evolution of our industrial organisations, these men are developing greater intelligence and superior ability to those who have preceded them. Thus the fittest survive.

In life nothing is stationary; contraction or expansion goes on continuously, and if you do not expand, you contract. It is so with nations, and it is so with industry. There are periods of expansion when the mills are running full, and there are periods of contraction when the number of unemployed is large. Confidence is at the foundation of expanding business activity. The amount of business transacted on credit is over two thousand times that transacted in exchange for gold or silver. If there is confidence, the manufacturer employs many hands, the labourers purchase more, the retailer buys more goods, the jobber orders more from the manufacturer, the manufacturer, to still further increase his output, employs more hands, and every man who wants work can find it. This is prosperity.

Lack of confidence causes contraction,—the manufacturer is afraid to make many goods; discharges some of his labourers; they purchase less; the jobber cancels his orders; the manufacturer must still further reduce his payroll. The result is "hard times."

In view of the fact that the maintenance of high wages in the United States is largely dependent upon our increasing exports, the question is asked whether we could sustain them in competition with the cheap labour of China, were China to become a manufacturing country. The best answer is that last year, among our other exports, we shipped two hundred million yards of cotton cloth to the Chinese. The average rate of wages paid by us in its manufacture was seven times the average rate of wages prevailing in China.

The Chinese, like the people in our own country who have a Chinese cast of mind, do not recognise the advantages of combination. Industrially, they are living in the land of yesterday, instead of in America, the land of today and to-morrow. Notwithstanding her great agricultural and mineral wealth, notwithstanding the fact that she has the largest body of cheap labour in the world, China is not an efficient competing factor in the field of production, because, in spite of all these facilities, she has none of the antecedents, intellectual, political, financial, or mechanical, for large scale production under modern conditions, since she possesses none of the instruments of commercial greatness and social well-being. Twenty centuries of stationary

policy and of looking backwards have made political progress and economic development impossible for China. She has remained in industrial infancy. Lacking organisation and all that goes with organisation, production on a large scale, aided by large aggregations of capital, and under conditions which attract and ennoble the greatest abilities, her agricultural and mineral wealth and her cheap labour cannot save her. She is left utterly behind in the economic race.

Our contractionists would practically have us put a wall around the United States which would reduce wages and prevent the working out of our destiny as a world power in commerce, in finance, and in the great and nobler field of doing our part in the advancement and civilisation of mankind.

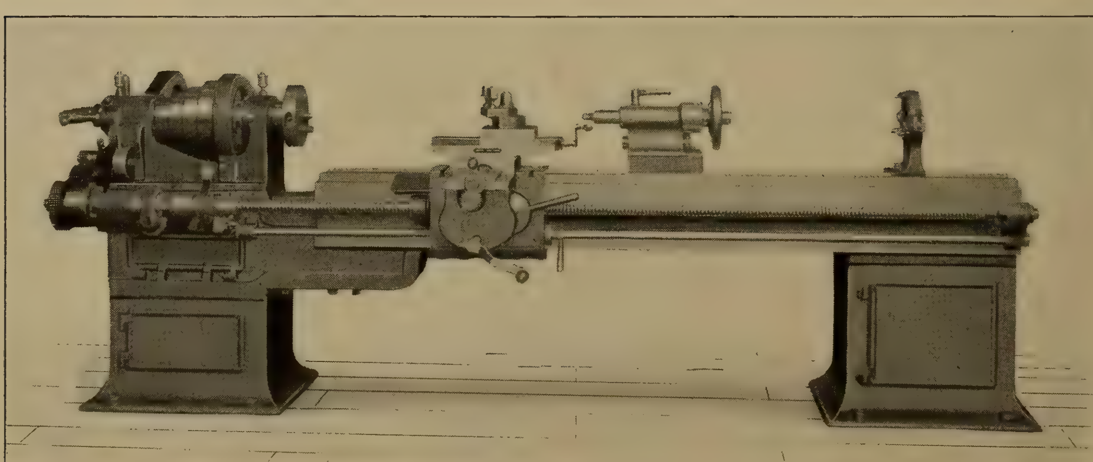
Situated as we are, between the great oceans, combining the strength of a great land power with that of a great sea power, we are pushing our way across the Pacific as we have already done across the Atlantic. But this increase is small compared with the increase that is destined to take place when no question is being raised as to the stability of the foundations on which rests this great industrial prosperity.

With our untold natural resources, with our inexhaustible supply of metals and coal, with our great forests, with every variety of soil and climate, with the most industrious, most intelligent and most contented of peoples, working under the best conditions of modern methods, we are destined to become the economic masters of the world.

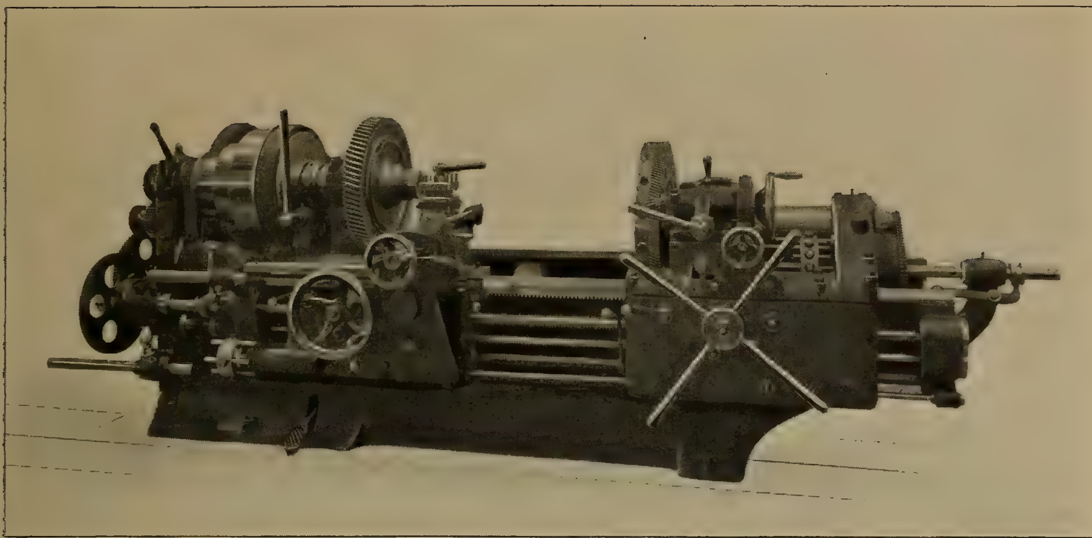
MACHINE TOOLS AT THE PARIS EXHIBITION

By Joseph Horner

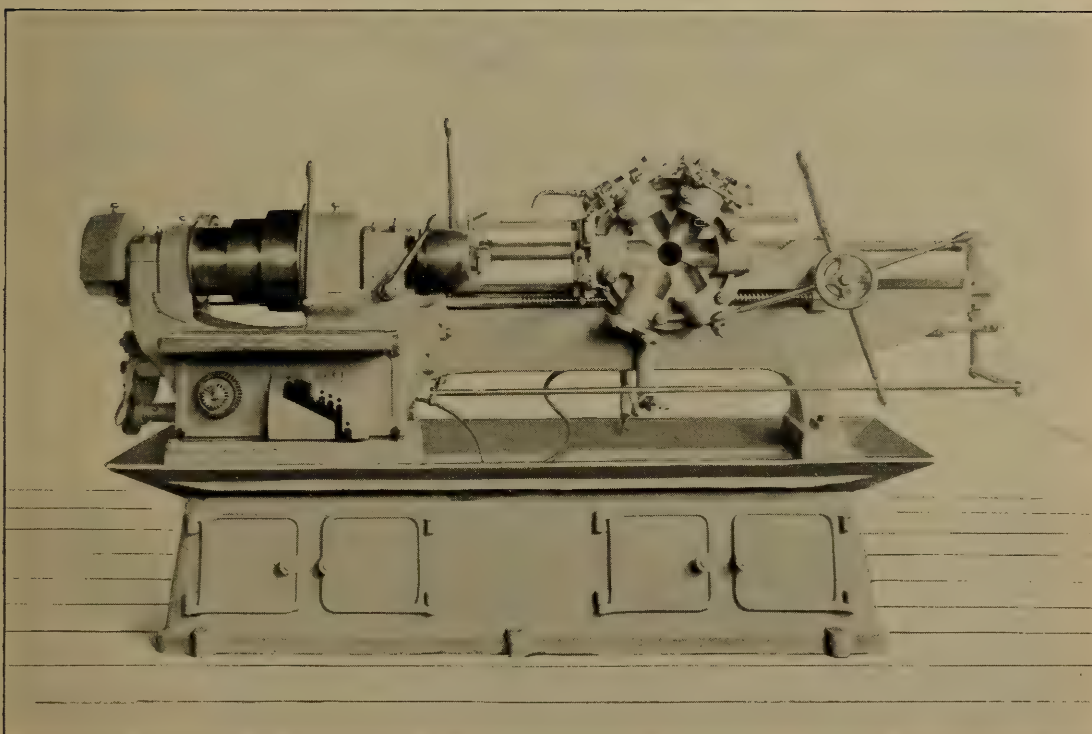
AS supplementing the remarks on foreign machine tools at the Paris Exhibition which appeared in the November number of this magazine, there are given in the following pages a number of additional illustrations and particulars, relating chiefly to some rather special types of tools of which Mr. Horner made notes while at Paris. The points of difference between these and the standard forms are such as to attract immediate attention; indeed, the designs become more interesting the more they are studied. The selections have been made from a large collection of machine-tool material gathered by Mr. Horner, and represent, as might be expected, only a very small part of



A FRONT SLIDE LATHE. BUILT BY THE DRESDEN BOHRMASCHINENFABRIK, DRESDEN, GERMANY



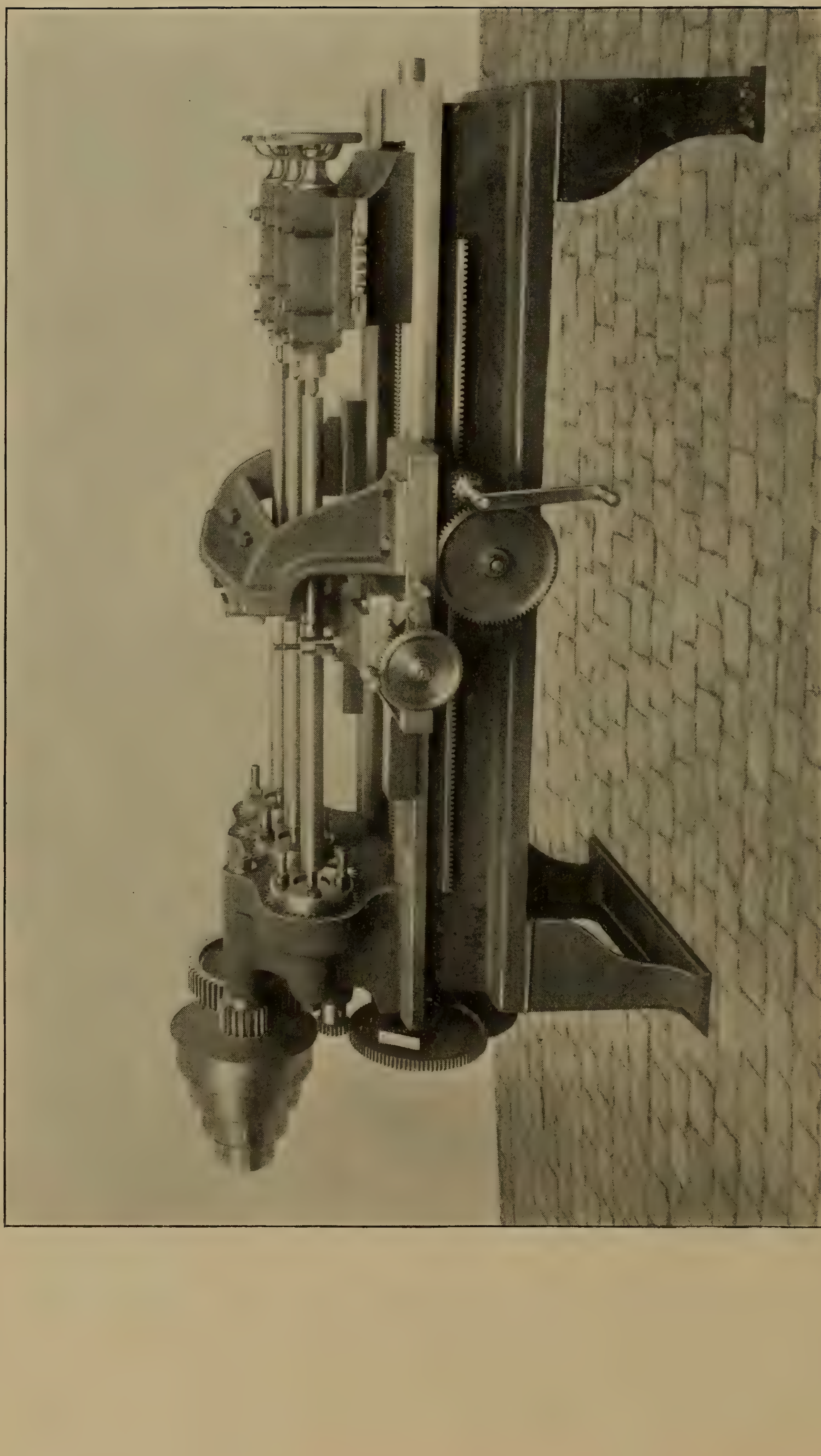
HEAVY TURRET LATHE BUILT BY THE PITTLER COMPANY, LEIPSIC, GERMANY



VERTICAL CROSS TURRET LATHE BUILT BY THE WOLSELEY SHEEP SHEARING MACHINE COMPANY, BIRMINGHAM, ENGLAND

all that was interesting and instructive in this class of exhibits.—THE EDITOR.

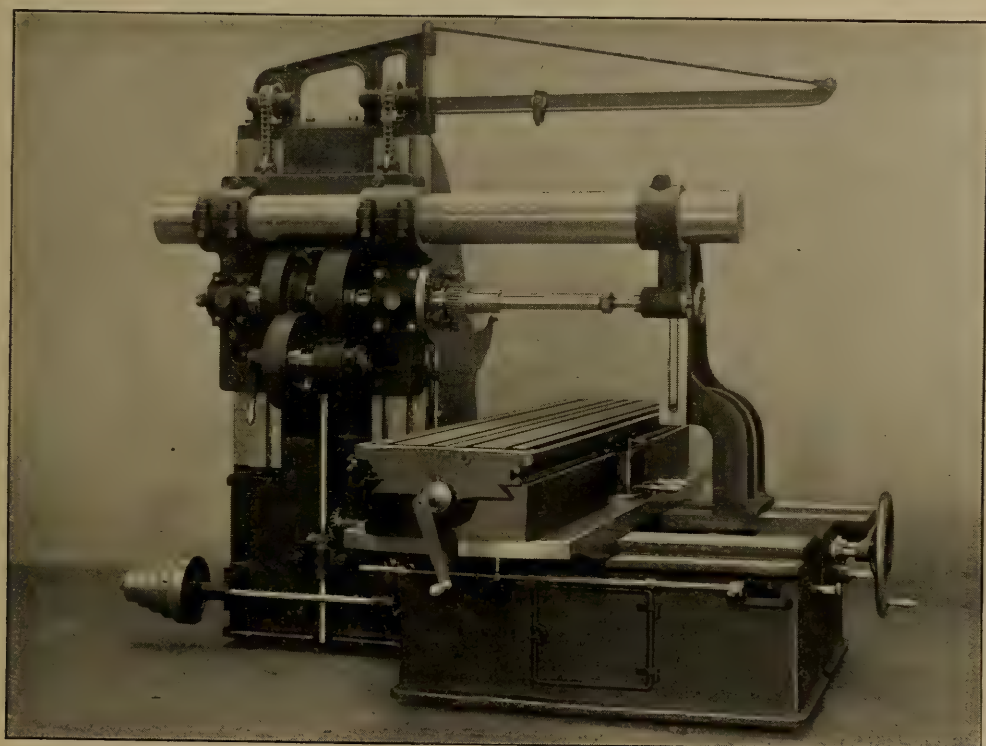
A three-spindle turning and screw-cutting lathe, shown at the stand of the Ateliers Demoor, of Brussels, presented several noticeable features. An illustration of this lathe is given on page 110. The spur gears by which the three sets of double drivers in the headstock are actuated are protected by enclosure in the head, the driving plates alone projecting. The triple-head, movable poppet slides on raised vees, while the carriage of the rest moves on another pair of vees which flank the first named. Each poppet barrel is capable of independent movement on the common base for taper turning. The lead screw, by which the carriage of the rest is travelled longi-



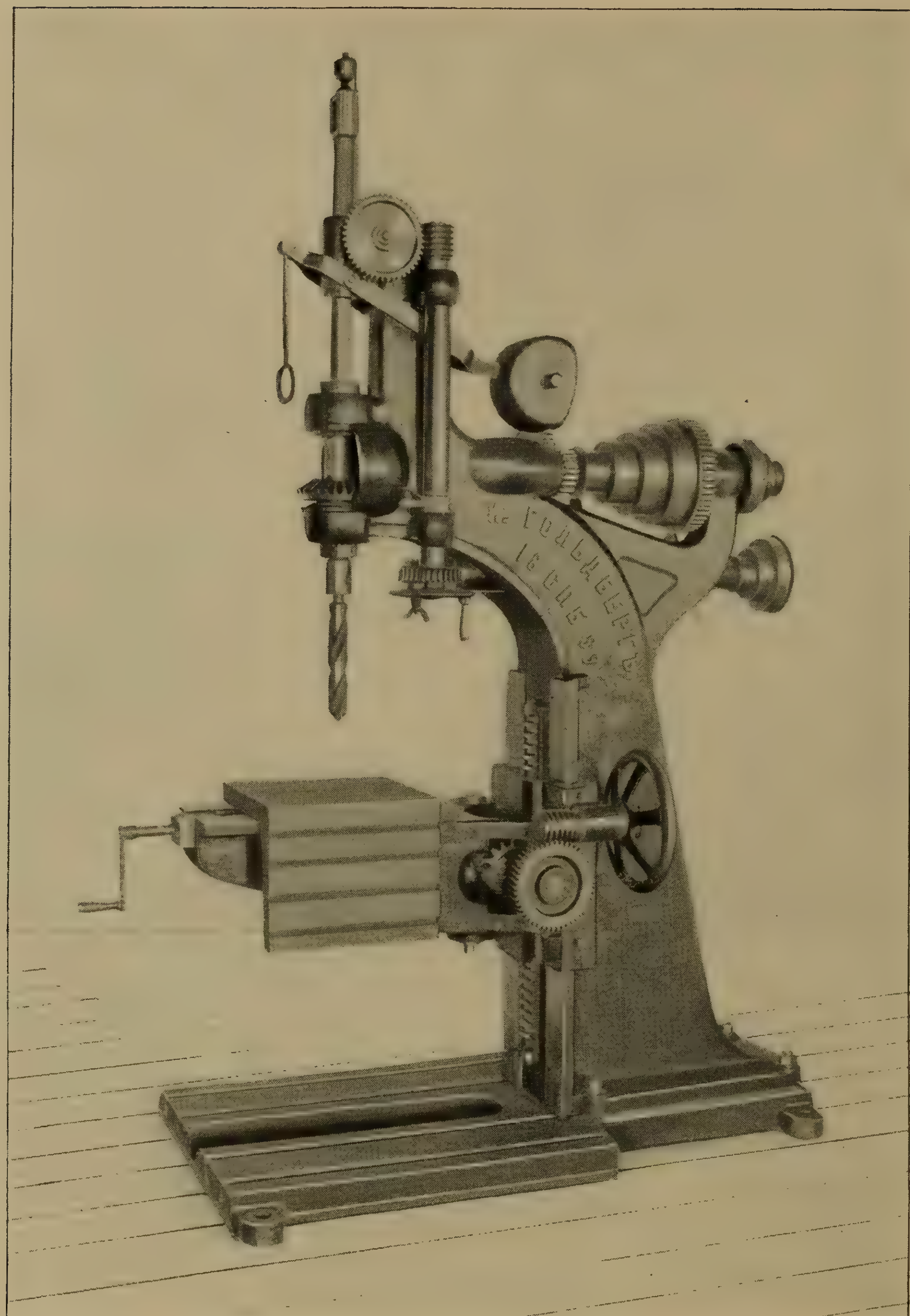
A THREE-SPINDLE LATHE BUILT BY THE ATELIERS DEMOOR, BRUSSELS, BELGIUM.

tudinally, both for turning and screw cutting, lies down the centre of the bed. It is driven through change gears at the left-hand end, rapid return and rapid adjustments being effected by rack and pinion. The three rests are regulated independently, but act simultaneously. There is also a quick withdrawal for screw cutting. This is a stiff and most useful machine, which should give a good account of itself in the turning of shafts, spindles, and rods.

The vertical cross turret lathe and automatic screw machines of the Wolseley Sheep Shearing Machine Company, of Birmingham, England, were marked by originality in the working out of details. They are unlike any others, notwithstanding that they embody well-known arrangements. The vertical cross turret machine, of which an illustration is given on page 109, possesses the advantage that the cutting is done very low down, a position favourable to heavy tooling and to easy movement of the slide, and also that the chips fall clear at once of the tool and turret into the pan beneath, instead of obstructing the bed and the view of the work. The massive turret,—18 inches in diameter,—is carried on a long slide upon a single broad bed shear. It is rotated automatically, and in either direction,—an advantage when two or three tools only are being used. The lead screw is brought very close to the slide. The chuck and roller feed are operated simultaneously by the same lever, and the head is friction-back-geared. The chuck body is forged solid with the spindle. Various jaws can be used,—ten sets being supplied for stock, ranging from 5/8 in. to 2½ in. Two feet in length is the maximum capacity of the machine. The change gears are fitted to give twenty-four rates of pitch, the same being used for feeding. The lead screw is reserved for screw cutting, and the reversing motion of the turret slide is such that in cutting threads which are not multiples of the pitch of the lead screw the tool drops in the right place. The return motion is effected rapidly. Turning is by feed rod,—chain driven, and through worm gear. The headstock and bed are cast in one piece.



MILLING MACHINE WITH SWIVEL CRANE. BUILT BY J. E. REINECKER, CHEMNITZ-GABLENZ, GERMANY



A RUSSIAN DRILLING MACHINE. BUILT BY ISIDORE GOLDBERG, ST. PETERSBURG

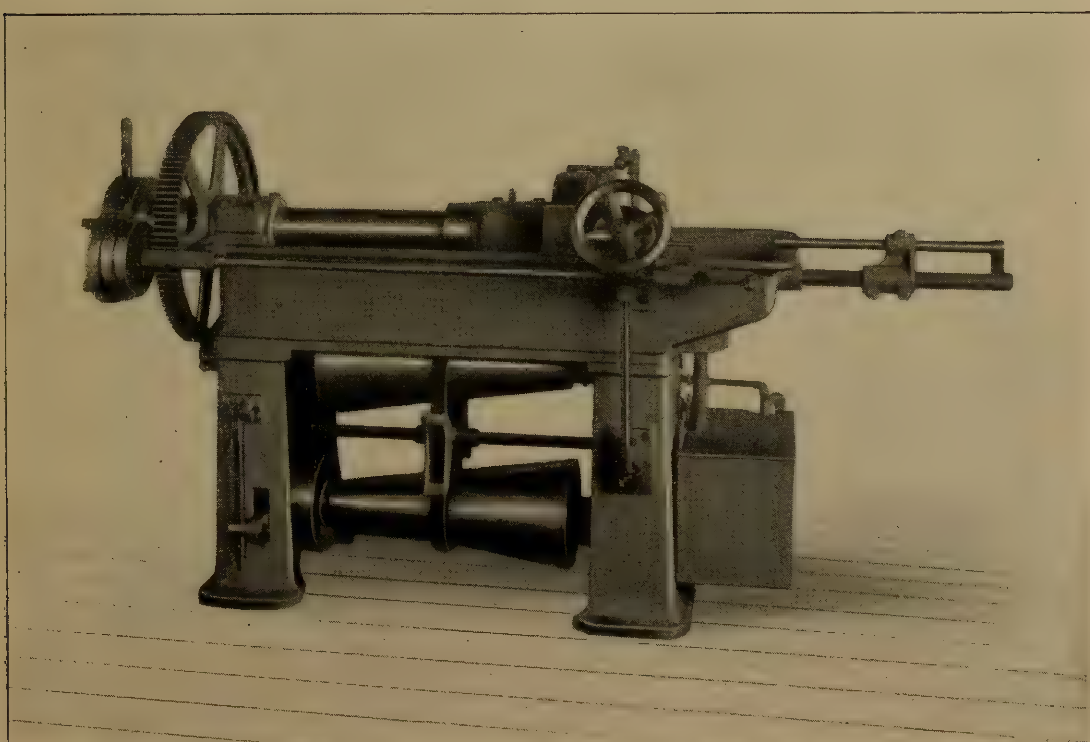
This lathe is intended for bar work only, up to 2½ inches diameter, and is designed not only for repeat tasks, but for those also in which only a few pieces are required, these being done more cheaply thus than on an ordinary screw-cutting lathe.

An interesting exhibit of lathes with truncated, triangular beds and swivelling rests was made by the Pittler Company, of Leipsic, Germany. But the new turret machine of this firm, shown on page 109, was the most striking object at their stand. It is crammed so full of mechanism that its capabilities can only be summarised here. The turret, which is vertical, carries sixteen tools, and for each tool there are two separate stops, arranged in two sets, one for longitudinal turning, and one for depth. The first are carried on a disc, which is on the same spindle as the turret. The second are placed at the back of the disc, in tee slots which

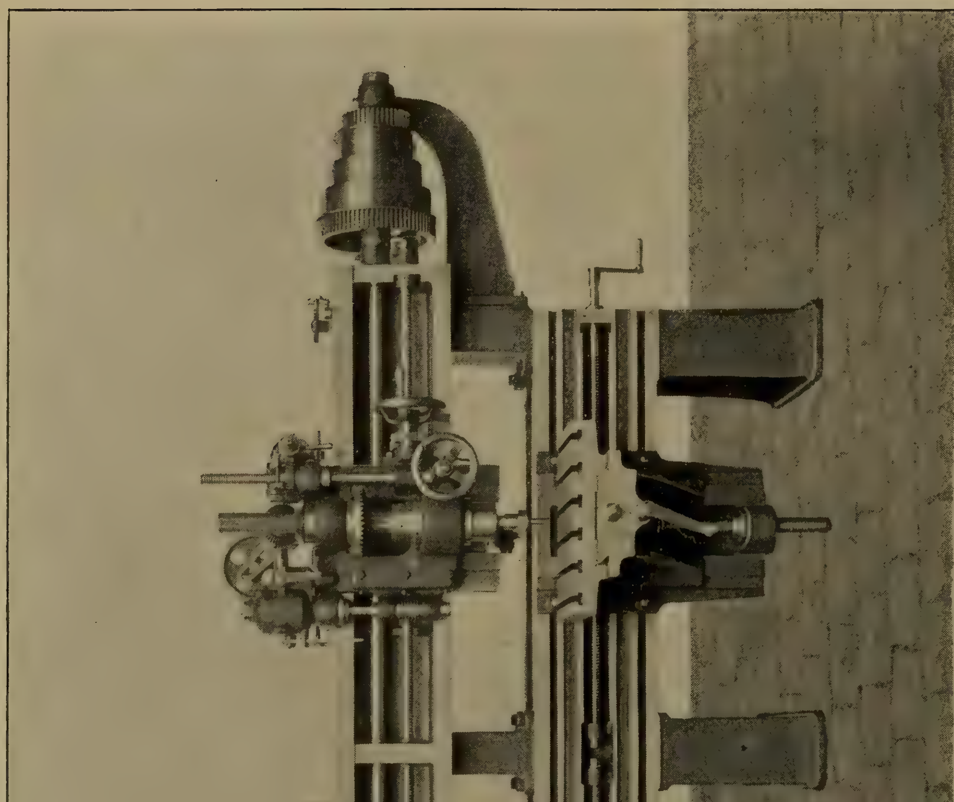
are capable of a coarse setting by spanner, and of fine adjustment by screw. There is also a stop for centering the tools. Each of the turret tools is carried in a circular holder which rotates in the head, by which device the tools are rapidly set to suit the work. Separate tools are retained for roughing and finishing, and, by the aid of the cross slide, as many as five can be operating at one time on some classes of work. The turret is adjusted by hand through the ring of teeth cut round its edge, and actuated by a pinion. By means of the cross handle in front, the carriage and turret, with fittings, is racked rapidly along the bed. The lathe has a hollow spindle for bar work, with automatic chuck and wire feed, but is equally adapted for castings.

A Pratt & Whitney tool which is superior to the power hack saw, is the cutting-off machine shown on this page. It is fitted with mechanism for accelerating the speed as the cutter moves from the circumference to the centre of a bar. As the centre is approached the speed is increased by means of reverse cones, seen beneath, the belt of which is pulled along by a screw operated by gears, automatic in action, but which can be thrown out instantly by dropping a lever. A bar 3 inches in diameter can be cut off in about seven minutes. The tool is lubricated by a pump, is well supported on a rest, and the driving cones are carried at one end by springs to prevent jar. This method of cutting off is better than using a hack saw, because a fine finish is left on the severed faces, the action being that of turning.

Front slide lathes were shown by the Dresden Boring Machine Company, of Dresden, Germany, one of them being illustrated on page 108. This design lessens the friction of chips over the shears, permits the saddle to be moved past the poppet, and allows the lead screw to be placed in the centre of the saddle. In addition, the lathe embodies modern devices for effecting automatic movements and facilitating changes of feed and speed. The back gear is thrown in and out without stopping the lathe by means of a patented arrangement of sliding levers and pins. The poppet is of the usual Continental build, with solid spindle.



CUTTING-OFF MACHINE WITH ACCELERATING MECHANISM. BUILT BY THE PRATT & WHITNEY COMPANY, HARTFORD, CONN., U. S. A.



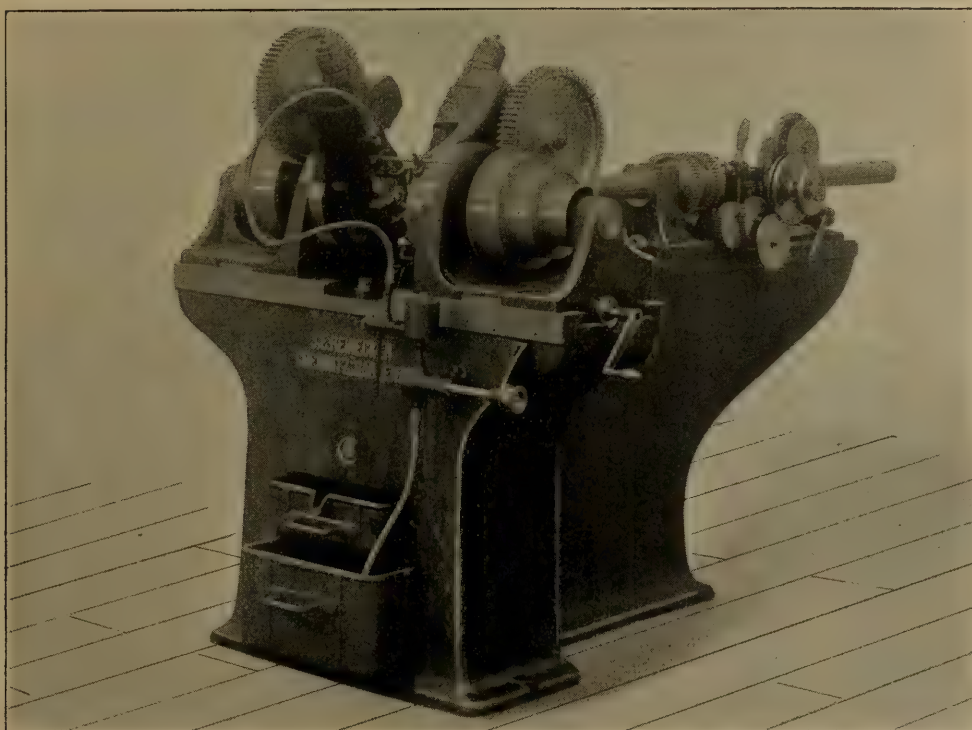
TWO-SPINDLE MILLING MACHINE BUILT BY THE ATELIERS DEMOOR, BRUSSELS, BELGIUM

The gap and the cabinet legs are British and American, respectively.

Although multiple spindle drilling machines are among the most useful and common machine tools, not very much of striking character was shown in this line at Paris. The most interesting were some German machines, in which the drill spindles were adjustable in circles and squares, and, in fact, in nearly any polygonal arrangements, which made them of special value for drilling a number of bolt or stud holes simultaneously in a flange, or in any number of flanges, all of which would then be precisely alike in regard to centres. The spindles were driven through universal joints, and, when set, they remained in the same centres until altered again by the attendant. The machines are built with varying numbers of spindles. When the number in a machine is not equal to the number of holes required in a circle they can be set to drill every alternate hole, so that in such a case a flange would have its holes drilled in two operations. The drill spindles can be set in line to a limited extent. Machines of the same type are made with horizontal spindles to drill the flanges of long pipes.

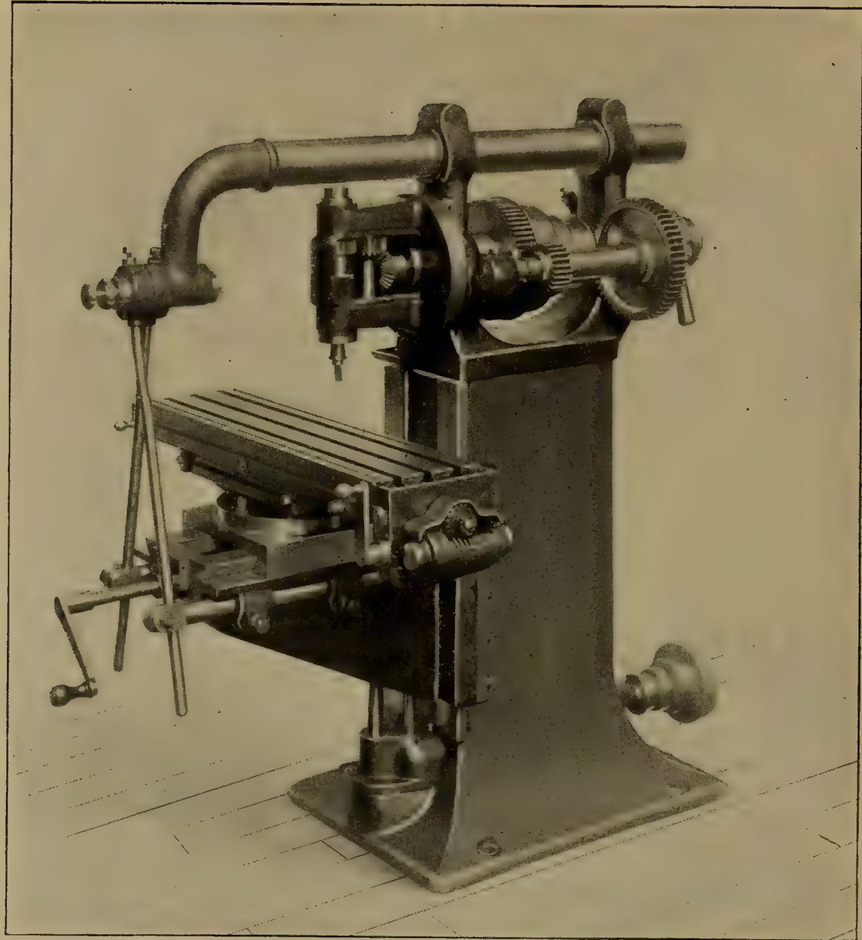
The drilling machine shown by Isidore Goldberg, a St. Petersburg firm, page 112, represented an interesting sample of Russian workmanship. It follows closely the British model, but the spindle bevel gears are partly protected. The gear teeth are of involute form.

The great development in milling machines of late years was strikingly apparent at Paris. There were many of these that indicated the high-water mark of present practice; and they were not confined to one country, but were sent by British, American, French, and German firms.



MACHINE FOR GROOVING TWIST DRILLS. BUILT BY J. E. REINECKER, CHEMNITZ-GABLENZ, GERMANY

The Ateliers Demoor, of Brussels, had a double-spindle milling machine at their stand, shown on page 114, specially designed for cutting keyways and slots. It is a good specimen of Belgian workmanship. It embodies a horizontal girder mounted on standards, which carries upon its tee grooved, vertical face the two knees upon which the work is bolted. These are similar in design to those used on shaping machines, having compound tables with horizontal,



MILLING MACHINE BUILT BY THE DRESDEN BOHRMASCHINENFABRIK, DRESDEN, GERMANY

vertical, and transverse motions. Above the bottom girder is mounted the rail that carries the two spindle heads. The rail is supported both at the ends and at the centre. The heads are screw-driven from back-geared cone pulleys,—one at each end of the rail. Each pulley drives its own head, independently of the other, and each table is adjustable longitudinally by means of separate hand screws. The tool heads have automatic arrangements for changing the longitudinal movement for a drilling feed, as well as for key-grooving. Longitudinal and vertical adjustments can also be made by hand. All movements are operated from the tool head, hand wheels being so placed that the attendant need not move away from the work to effect them. The maximum distance between the tools is slightly over 8 feet.

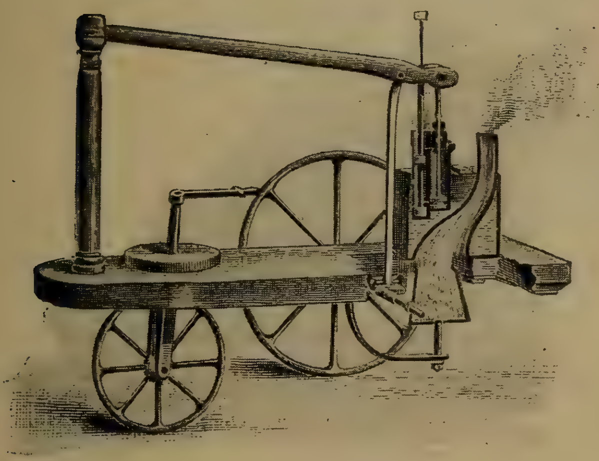
The milling machines of J. E. Reinecker included one of large dimensions, shown on page 111, fitted with a swinging crane. Another, of special design, shown on page 115, was a beautifully constructed machine for grooving the flutes of twist drills.

The milling machines shown by the Dresden Boring Machine Company, one of them illustrated on this page, are fitted with a head which swivels to any vertical angle, so that horizontal, vertical, or angular milling can be performed. The arm and horizontal arbour are steadied by round rods which pivot on the arm, and are thus adjustable at all heights of the table, being clamped below in split bosses in rods which are clamped, in turn, to the knee.

Grinding machines of all kinds were well shown at Paris, running probably into hundreds in all. But the really good machines for precise work were not numerous. There was nothing better to see than the well-known types and those which were modelled after them.

THE STEAM AUTOMOBILE

By J. A. Kingman



MURDOCK'S ROAD LOCOMOTIVE, 1784

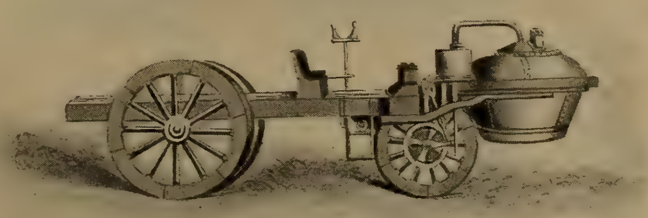
THE application of steam as a motive power for road vehicles is not a new thing. It is not even modern, for the first successful steam carriage was built over a hundred and twenty years ago. The power of steam was well known to the ancients, and from the time of Hero to the latter part of the eighteenth century we find numerous allusions to the possibility of steam as a prime mover.

James Watt, in one of his letters, wrote:—" My attention was first directed to the subject of steam-engines by the late Dr. Robinson, then a student of the University of Glasgow, afterwards professor of natural philosophy in the same institution. He, in 1759, suggested the idea of applying the power of the steam-engine to the moving of wheel carriages and to other purposes, but the scheme was soon abandoned on his going abroad." It will be noticed that this suggestion of Dr. Robinson antedates Watt's experiments on the steam-engine, and may have influenced his remarkable series of inventions.

The first steam automobile was built in France in 1769 by Nicholas Joseph Cugnot, a French military engineer, after his retirement from the army. The vehicle was built with public funds, Cugnot having interested the Minister of War in the matter. The first carriage was unsuccessful, either on account of the small size of the boiler or of inefficient feed pumps. It could not run for more than a short distance without stopping to get up steam. It possessed considerable power, however, and broke down a stone wall in one of its erratic journeys. A second machine was a three-wheeled vehicle, the boiler being placed in front and the forewheel driven by a double-cylinder engine. This carriage, together with an excellent model of it, is now preserved in the Conservatoire des Arts and Metiers at Paris. Cugnot may thus be credited with having made the first successful steam motor carriage.

In England, Watt was apparently too much engrossed with other work to pay much attention to steam carriages. He applied for a patent for one in 1781, but there is no record of his having followed up the matter further. In later years Watt was opposed to steam carriages and would not let them pass his residence.

In 1772 Oliver Evans, in America



CUGNOT'S EARLY ROAD LOCOMOTIVE

started his investigation of the steam-engine. In 1776 he petitioned the Legislature of Pennsylvania for the exclusive right to use his invention for flour mills and steam carriages. The petition

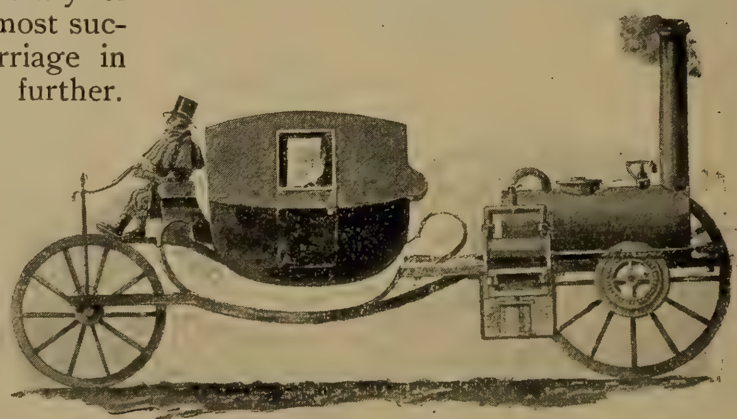
GURNEY'S STEAM CARRIAGE, 1827

was partially granted in 1787, but the steam carriage part of it was entirely ignored. The Legislature of the State of Maryland granted a similar petition in 1787. Evans succeeded in making for the Board of Health of Philadelphia a curious steam dredging machine, which, when finished, was mounted on wheels and run by steam from the shop where it was built to the water, a distance of a mile and a half. There the wheels were removed, the boat was launched, and steam was used to turn the paddle-wheels.

Returning to England, we find that William Murdock, a contemporary of Boulton and Watt, made a most successful model of a steam carriage in 1784, but did not proceed further. William Symington, who built the first practical steamboat ever made, also made a model in 1786 which gave excellent results. No successful steam motor carriage was, however, made in England until 1801, when Richard Trevithick produced a steam carriage, which, although crude in the extreme, was a practical locomotive. This carriage was first tested on Christmas Eve, in 1801, and ran for several trips. Trevithick's success was very marked, and much is due to his experiment. He was the first to introduce exhaust steam in the smoke-stack. Still another carriage intended for use on common roads was that of Julius Griffith, built for him by Bramah in 1821. The whole outfit was of excellent design and construction. The boiler, however, was so designed that it made the regular generation of steam impossible, as water was expelled from the tubes and could not be re-introduced. Although the carriage was often experimented with in the yard or shop grounds where it was constructed, there is no record of any trips or tests being made.

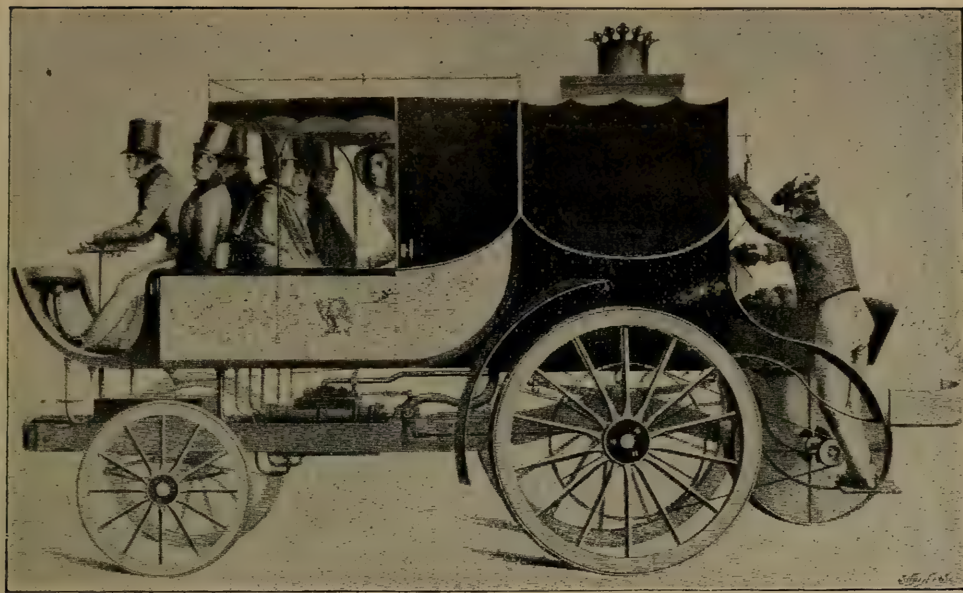
From the time of the construction of Griffith's carriage, in 1821, until 1840 steam carriages were built for operation on common roads. Most of these were experimental and were built by private individuals at great labour and expense. All were heavy and clumsy, and could not run more than seven or eight miles without stopping to take on fuel and water. As a rule, they were mechanically successful and could run at rates of speed ranging from eight to twenty miles an hour.

J. Scott Russell, who designed and built the *Great Eastern*, built also a number of steam coaches of excellent design. These were run successfully



SYMINGTON'S STEAM COACH, 1786

between Glasgow and Paisley until hostile legislation prevented their further operation. Sir James Anderson, an Irish baronet, devoted thirty-one years of his life to steam carriages and spent £30,000 on experiments, but



SQUIRE AND MACERONI'S STEAM CARRIAGE, 1833

achieved little or no success. Undoubtedly the three most successful early builders of steam carriages were Gurney, Hancock, and Maceroni. Of these three, Gurney has received the most credit, and at one time a committee from the House of Commons recommended a grant of £16,000 as reimbursement for his expense in experimenting with steam carriages. Sir Goldsworthy Gurney started his experiments in 1825, and built steam coaches until 1832. They were fitted with his patent water-tube boiler, and with slide-valve engines, a feature of the boiler being a system of chambers or separators to prevent priming. Steam could be raised in about five minutes, under favourable conditions.

In 1831 Sir Charles Dance started a steam stage-coach line between Gloucester and Cheltenham, using Gurney's coaches. The line was successfully operated for four months, when determined opposition, coupled with excessive turnpike tolls, caused the venture to be abandoned. At one time eighteen inches of broken stone were laid on the Gloucester road, and the carriage, loaded with twenty passengers, twice ploughed through the obstruction; but the strain so weakened an axle that it broke. During the existence of this stage-coach line 396 journeys were made, covering 3644 miles in all. Four hundred passengers were carried, and £78 were expended for coke, or about 5d a mile for fuel.

In 1831 Gurney petitioned to have the excessive rates of toll removed. In the same year a select committee of the House of Commons took evidence for three months from the leading steam carriage builders and civil engineers of the country. Among these were such men as Davies Gilbert, M. P., president of the Royal Society; Thomas Telford, president of the Institution of Civil Engineers; James MacAdam, inventor of the macadam pavement, and others of similar standing. This committee inquired most thoroughly into the proportion of tolls which should be imposed upon coaches and other vehicles propelled by steam upon turnpike roads, also the rate of tolls actually levied, and, further, into the state at that time and future prospects of the steam carriage on common roads. Their conclusions were,—

1st. That carriages can be propelled by steam on common roads at an average rate of ten miles an hour.

2d. That at this rate they have conveyed upwards of fourteen passengers each.

3d. That their weight, including engine, fuel, water and attendants, may be under three tons.

4th. That they can ascend and de-

A STEAM CARRIAGE RUN IN THE CITY OF NEW YORK BY ROBERT DUDGEON NEARLY FIFTY YEARS AGO

scend hills of considerable inclination with facility and safety.

5th. That they are perfectly safe for passengers.

6th. That they are not, or need not be, if properly constructed, a nuisance to the public.

7th. That they will become a speedier and cheaper mode of conveyance than carriages drawn by horses.

8th. That, as they have a greater breadth of tire than other carriages, and as the roads are not acted on so injuriously as by the feet of horses in common draught, such carriages cause less wear of roads than coaches drawn by horses.

9th. That rates of toll have been imposed on steam carriages which would prohibit their being used on several lines of roads, were such charges permitted to remain unaltered.

A bill for the repeal of the "Turnpike Act" was twice referred to a select committee, but did not pass the House of Lords. On the failure of this bill Gurney gave up the manufacture of steam carriages. Walter Hancock was the most successful builder of steam carriages in England at this date. He built ten carriages, nine of them large omnibuses, and the last two carriages were successful in every way. Hancock began working on steam carriages in 1825, and continued his labours until 1840. The boiler employed by Hancock consisted of a series of chambers arranged vertically. The bosses of one chamber rested against the bosses of another, the whole being stayed by strong bolts. The engine had two cylinders and was placed vertically, motion from the crankshaft being communicated to the rear axle by a chain. It is stated that Hancock was the first steam carriage builder to run his carriage in the streets of London, where they were operated without noise, smoke, or appearance of steam. They did not frighten horses, and created a most favourable impression. Hancock's carriage ran between London and Paddington for five months. The London & Paddington Steam Coach Company was

formed with the intention of using Hancock's machines, but the company treated Hancock in anything but a business-like way, retaining one of his carriages for a considerable period for the purpose of taking it apart and copying it. Many important improvements were introduced by Hancock, and his carriages were very successful, mechanically. He introduced exhaust steam into the fire, and it was usually invisible. The safety valve was arranged to blow off in a separate box. The system of springs used was excellent.

The connection of Colonel Maceroni with the manufacture of steam carriages has been more or less ignored by historians. Maceroni built two of the best steam carriages ever made, although he was handicapped by lack of funds. He was also particularly unfortunate in business ventures, and did not succeed in making more than two vehicles. The arrangement of his machinery was very compact, and Gordon describes the carriage as being "a fine specimen of indomitable perseverance." The boiler was an excellent one, of the vertical water-tube type, with steam connections at the top and water connections at the bottom. It was fitted with a steam dome. A pressure of 150 pounds was carried. The vehicle ran with great speed, twenty miles an hour being often attained.

TANGYE'S ROAD LOCOMOTIVE "CORNUBIA," 1862

Maceroni and Squire were in partnership for a considerable period. After this partnership was dissolved Maceroni became short of money and allowed a man named Asda to take the two carriages abroad. Asda agreed to pay Maceroni a certain percentage of the price received for patents, and departed. The carriages created a sensation on the Continent, and Asda was successful both in the demonstration of the capabilities of the vehicle and in the sale of the patents. On his return, however, he refused to make any settlement with Maceroni, and took all of the money, as well as the credit, to himself.

Since, then, up to that time a number of successful steam carriages had been built, the question naturally arises why the steam carriage industry did not have a natural and steady growth instead of dying out completely about the year 1840? This question cannot be answered off-hand, as the failure of steam carriages was due to a variety of reasons. There were, to begin with, poor roads. The condition of roads in Great Britain at that time was generally bad, and the excessive vibration caused by travelling at a fairly good rate of speed was too much for the machinery, so that repairs were frequently necessary. Rubber tires had not yet been invented, and springs were just beginning to be used. The steam carriage industry, moreover, was strongly opposed by numbers of country gentlemen, landlords, stage-coach companies, and others who did all they could to have the steam carriages turned off the roads. Excessive tolls were a direct result of this opposition, and it is said that at one time there were no less than forty bills presented to Parliament for

A LOCOMOBILE IN MOUNTAIN SERVICE

the purpose of having steam carriages removed from common roads.

Then, too, there was the unfortunate tendency of inventors to disregard previous inventions. Many of the builders of steam carriages at that time were unwilling to accept well-tried ideas, but went their own way, trying to introduce their own patents. As a result, almost all the steam carriages built were, in every particular, experiments, instead of being an assemblage of tried devices with a few improvements or later inventions.

Another factor opposing steam carriage progress was the growth of the steam railway. Following Stephenson's successful run with his locomotive, *The Rocket*, in 1829, this growth was very rapid. The leading scientific and moneyed men devoted most of their time to this subject, and in consequence the steam carriage naturally suffered.

There are few records at this date of any accidents with steam carriages. While Roberts was running a steam carriage in the streets of Manchester, several of the boiler tubes burst, but the accident was a slight one, though greatly exaggerated at the time. Little damage was done. A serious accident, however, happened to one of Scott Rus-

sell's steam carriages while running from Glasgow to Paisley. Somebody, opposed to the steam stage-coach line, had placed eighteen inches of broken stone in the road, and, while ploughing through, the carriage was overturned, and the great weight resting on the boiler caused it to explode. Several of the passengers were killed and others injured. In 1840 the subject of steam locomotion on common roads ceased to be a matter of public interest, and from that time on there was no marked development other than in connection with the traction engine. The steam carriages of Rickets, Carrett, and others were simply traction engines arranged to carry passengers. In America, J. K. Fisher devoted much study to the steam carriage, although he was discouraged in his attempts by those who claimed that in Great Britain, on better roads, little or nothing had been accomplished. Fisher experimented as late as 1870 and produced several steam carriages, which were rather light and may be considered as generally unsuccessful. Other steam carriages were built in America during the period from 1840 to the present time, but most of these were experimental and were not permitted to run on the highways for any length of time. The steam carriage of Richard Dudgeon, shown on page 120, was built in the early fifties, and is still in excellent working condition. This machine was run in New York City and on Long Island, and it is at present stored at Locust Valley, L. I.

The regeneration of the steam carriage has been recent, and in great part has taken place in the United States. Three years ago there were probably less than a dozen steam automobiles in the country, while now there are about three thousand in actual use. This striking development has been greatly assisted by the introduction of liquid fuel and a wider knowledge of the properties of steam. Mention should be made of the excellent heavy steam vehicles of British manufacture, and the successful vehicles of DeDion and Bouton, Scott, Serpollet, and others in France, but the general tendency in these countries has been toward the development of gasolene carriages.

Serpollet invented his flash boiler in

A MODERN STEAM CARRIAGE, BUILT BY THE LOCOMOBILE COMPANY, OF AMERICA, NEW YORK

ON WINTER DUTY

the early seventies, and has worked consistently on steam automobiles. A boiler of this type must be expensive to manufacture, and the time required to heat the elements before starting may be considered a disadvantage, particularly in pleasure vehicles. The success of Serpollet, however, should stand as a proof of the desirability of steam as a motive power for automobiles. Probably few engineers will deny the statement that steam is the best power for heavy automobiles. The successful operation of steam trucks and omnibuses in Great Britain and France supports this view, particularly when we consider the almost general adoption in those countries of the gasolene motor for pleasure carriages.

Of the several thousand steam carriages of American manufacture a large number have been in use a long time, —certainly long enough to dispel any doubts regarding their practicability.

The results have been satisfactory to a high degree, both to the manufacturer and to the user. It has been demonstrated that the driver of a steam-motor vehicle need not be an engineer, and that carefulness and common sense are all that is required. The question of economy is not an important one, as the steam carriage may be operated by any one for less than a cent per mile per passenger, including lubricants.

The question of repairs is an interesting one. If a man expects to save money by disposing of his horses and adopting a motor carriage, he must give the latter good care and attention. Repairs are necessary to all machinery, but with proper inspection and maintenance, and common sense operation, the repair bill should be very small. Repairs to a steam carriage can be made almost anywhere, and this is an important advantage of the steam-driven vehicle.

As a hill-climber the steam carriage has proved its worth. Pike's Peak, in the United States, has been partially ascended, and an elevation of 11,000 feet has been attained. The highest peaks in the Yosemite also have been reached, and Mt. Washington has been ascended and descended twice by a steam carriage. In the 1000-mile trip of the Automobile Club of Great Britain, a steam carriage of American make competed against fifty-seven gasolene motor carriages, and its hill-climbing performances were a revelation. The steepest hill encountered on the trip was near Nottingham, and a record of the performances of the vehicles on this grade placed the steam automobile at the head of the list in a class by itself.

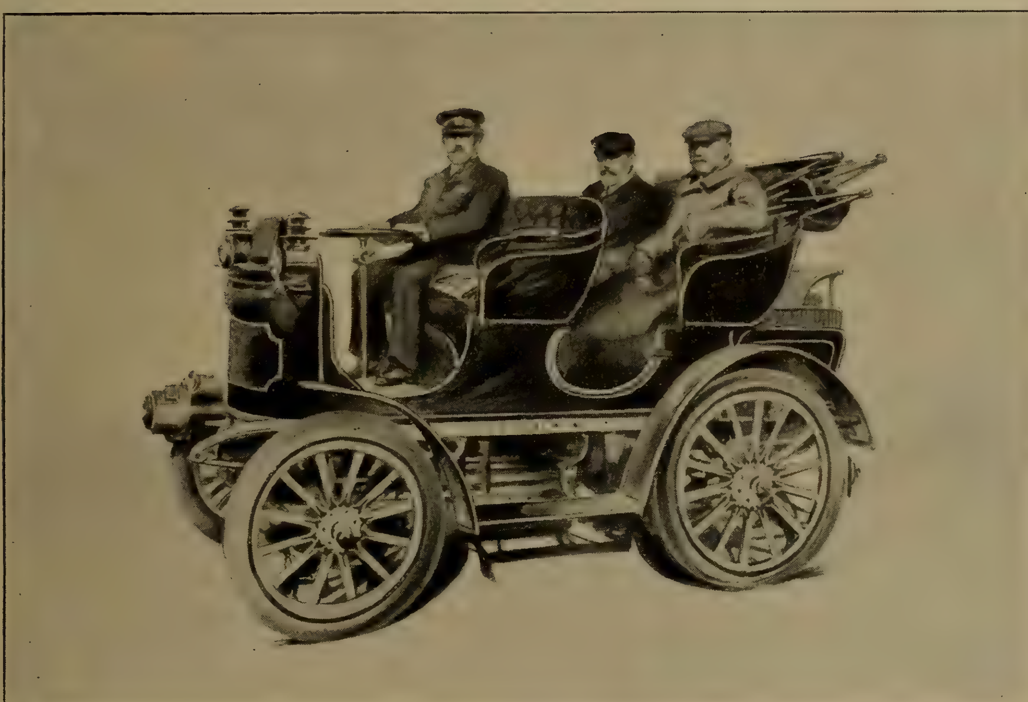
With the use of steam, great power can be stored in small space, and consequently the weight of a steam automobile is low,—much less than the

weight of an automobile driven by a gasolene or an electric motor. The reserve force in the boiler can be used to propel the carriage up a very steep hill, in which case the engine may be developing more than its indicated horse-power for a short time, and the boiler will supply a sufficient quantity of steam to the engine, provided the speed is not too great. Thus a four horse-power engine which may be developing but a single horse-power on a level road may be forced to do six or even eight horse-power. This flexibility of the steam system is an advantage.

A carriage driven by a gasolene motor does not possess this feature, and, consequently, in order to ascend the same hill at the same speed as the steam carriage, it must have an engine of greater horse-power. With increased horse-power comes an increase of weight. A standard type of gasolene phaeton of eight-horse power weighs about eighteen hundred pounds. A standard make of steam carriage of four horse-power weighs half this amount in service condition.

As to the electric carriage, the storage battery necessary to do the same work must be very heavy. The fault is not in the motor, this, indeed, being an ideal type, but in the battery, which, if forced, will be discharged too quickly, and this, as is well known, will ruin the cells.

Assuming, then, that the steam carriage has the advantage in weight, it follows that it is less expensive than the other types, and this is borne out in practice. The matter of speed is not important. It is requisite, however, that changes of speed be readily effected. A slight touch on the throttle lever of a steam carriage varies the speed instantly, and any speed from rest to the fullest capacity of the engine can be produced by this lever. It is an interesting sight to watch the performance of a steam carriage in a crowded thoroughfare. The speed can be varied so quickly as to give the operator thorough control of his machine, and it glides in and out among street cars and trucks like a thing of life. The carriage has a smooth motion, and the general adoption of the chain as a method of transmitting power has reduced the noise to a minimum. The exhaust is muffled and the quantity of visible steam is very small,—never



H. R. H. THE PRINCE OF WALES IN M. SERPOLLET'S STEAM CARRIAGE

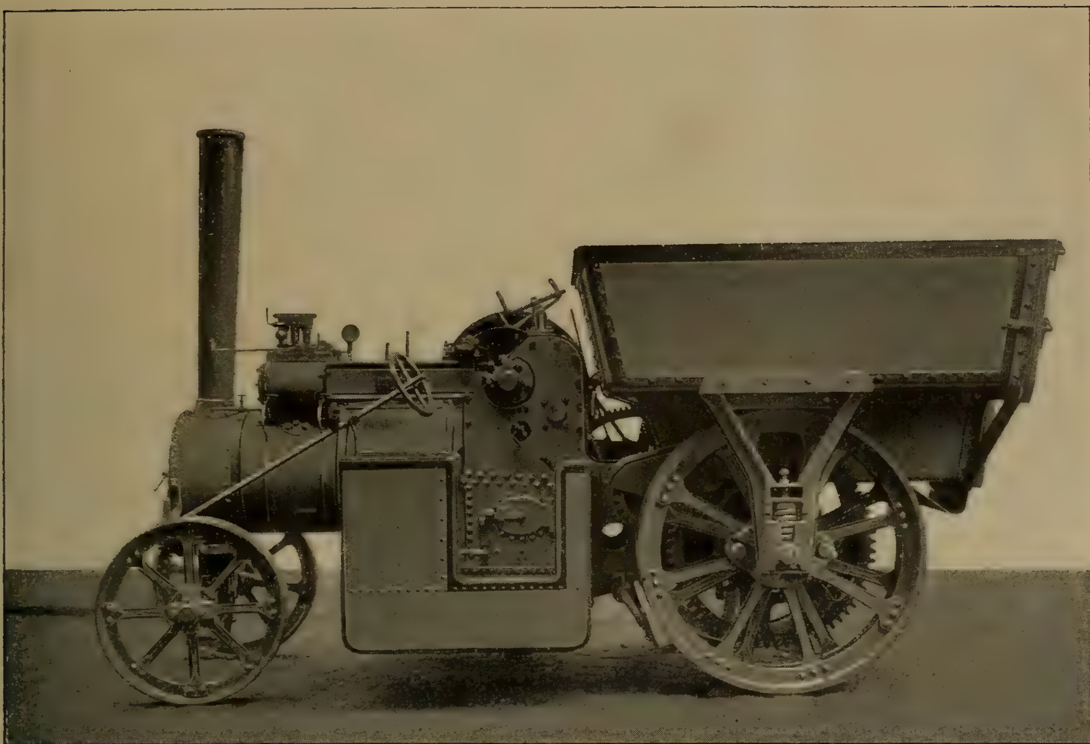
A STEAM TIPPING WAGGON FOR MUNICIPAL SERVICE. BUILT BY THE THORNYCROFT STEAM WAGGON COMPANY, LTD., LONDON

enough to frighten horses or to be considered as a serious objection.

A word as to generators! For automobile use the Stanley type boiler is, undoubtedly, the best known. It is of copper, of the fire-tube pattern, contains 44 square feet of heating surface, and weighs 100 pounds. Steam can be produced in less than five minutes from cold water, and the boiler seems to steam as well at one water level as another. It is absolutely inexplodable under all conditions. One of these boilers was tested to 1225 steam pressure, at which point no further increase in pressure could be produced owing to slight leaks. The boiler was then cooled, tested to 600 pounds cold water pressure, and is at present in regular service.

The engine for a steam automobile is preferably of the slide-valve type and need not be compounded. Two simple pressure cylinders are generally used. It must be remembered that the cylinders in a steam carriage are small and that the stroke is short; consequently the conditions are quite different from those ruling in a larger engine. Economy is not the most important consideration, and, generally speaking, it is not advisable to use a compound engine in a steam automobile. It is important that a steam-engine for automobile purposes should be of the very simplest type and one that can be most easily repaired. In a slide-valve engine fitted with a link motion, it is possible to vary the point of cut-off so as to work the steam expansively. It is very doubtful, however, if this is advisable, as the stroke of the piston is very short and the steam does not have much opportunity to expand. Moreover, when the engine is hooked up, the valves are given an excessive amount of lead, and unless the valve adjustment is very good, the engine will pound. When the valves are properly set and all the bearings and wearing parts are clean and well adjusted and thoroughly lubricated, the engine will run very easily and will use very little steam.

The ultimate success of any automatic boiler feed is very doubtful. Even though the boiler be fitted with a device of this nature, the water tank should have an alarm, otherwise the boiler will become dry. Generally speaking, auto-



A STEAM TIPPING CART FOR ROAD HAULING AND GENERAL FARM WORK. MADE BY MANN'S PATENT STEAM CART AND WAGGON COMPANY, LTD., LEEDS, ENGLAND

A STEAM OMNIBUS MADE BY THE POWER TRANSMISSION AND TRACTION COMPANY, YORK, ENGLAND

matic devices are not reliable, and must be watched if they are to give good results. It is advisable that the operator have control of the water supplied to the boiler. In going up a very steep hill it may be necessary to shut off the pump in order that the boiler may make steam faster; also in going down a steep grade, it ought to be possible to cut off the pump in order that the boiler may not be flooded. The operator of a steam carriage will not find it troublesome to regulate the supply and to glance at his gauge occasionally. A geared pump attached to the crosshead has been universally used, and this gives very good results, in spite of its small size. It is absolutely necessary to have two methods of filling the boiler with water, and a hand pump is probably better for this purpose than an injector. It is more simple, and can be operated by any one. An injector has not been used very much, the chief objection to it being that its orifices are small and apt to clog up. It is also apt to flood the boiler.

The subject of condensation has not received much attention. The exhaust from a steam carriage is practically invisible the greater part of the year, and in no case is it objectionable to the operator. A condenser of any type would certainly add cost and weight to the outfit. If a surface condenser be used, it would be necessary to separate the oil from the exhaust steam before returning the water to the reservoir. An atmospheric condenser would probably be better, as in summer the condenser is not needed, and in winter the low temperature would make this type very efficient.

In the United States the steam truck has not been developed to any great extent. It is obviously more expensive to experiment with a vehicle of this nature than with a small steam pleasure vehicle, and the conditions of operation, moreover, are entirely different. But as it is generally agreed that the demand for motor trucks and omnibuses is practically unlimited, and that steam is the proper power to use in heavy vehicles, substantial development may be expected before long in this field also.

MOTIVE POWER AND INDUSTRY

ENGINE TYPES AND THEIR INFLUENCES

By Alton D. Adams

ALL industrial operations require some expenditure of energy. The primitive occupations of man, such as agriculture, consume comparatively small powers, and these are of an irregular and intermittent character. As civilisation advances, the arts of weaving, wood, stone and metal working expand, and the question of power becomes more important. Most extensive advances in manufacture have been preceded or accompanied by a reduction of the cost or an improvement in the quality of the power consumed. In nearly every instance where a process of manufacture using a costly or inferior source of power has come into competition with a similar process using a cheaper or better power, the latter process has displaced the former. In a like manner, when a social condition among men, resting on the use of a more expensive power, has had to compete with another social condition, resting on a less expensive power, the former social condition has vanished. A glance at the past effects and some consideration of present tendencies and future results of changes in motive power are the object here.

The operation of simple machines by muscular energy is older than history. Familiar examples are the hand mortar for crushing grain, and the plough for tilling the soil. The fortunes of these two machines through the centuries illustrate well the influence of motive power on social conditions. The woman grinding corn remains in civilised countries only as a figure of history, but the farmer still follows the plough, much as he did when Europe was an unknown forest. The reasons are plain. The windmill and the water-wheel were early found to be cheaper than human effort for grinding grain, but only in exceptional cases does it pay to displace the ox or horse by a traction engine at the plough. As a result the grinder of grain works in a mill for a capitalist or a corporation, but agriculture may still be carried on by one who is independent, though poor.

Like the grinding of grain, the weaving of cloth, the working of metals, and the production of most manufactured articles have come under conditions where cheap power can be applied to them. The general tendency of motive power development has been to involve large amounts of capital for the economical production of energy and a high degree of skill in its operation. Thus the individual manufacturer has often found himself too poor in purse to secure an equipment for cheap power, and so lacking in skill as to be unable to operate such an equipment if he had it.

Again, the most economical power usually depends on its development in very large quantities, but such quantities would be of no use to the small manufacturer, even if he could make the investment necessary to produce them. The development of motive power has thus increased the capacity for production, not in proportion to the investment, but at a materially higher ratio. The employer of a thousand men can produce more cheaply than the employer of ten men, not necessarily because each of the larger number of men does more, but because the power for the work of

each costs less. Meantime, the cost of production at the smaller factories regulates the market price and the large works pay an extra dividend.

Other factors besides the low cost of power contribute to cheap production in large works, but cheap power is one important factor, and the only one to be considered here. In most processes of manufacture that can be carried on continuously in a limited space at a high rate of production, the energy of the winds, of falling water, or of chemical combinations of inanimate substances has proven much cheaper than the muscular exertion of man or beast. Unfortunately for the small manufacturer, cheap power in small units from any of these inanimate sources is one of the later, rather than one of the earlier, developments.

Wind is that one of the so-called natural forces that was, perhaps, first employed by man for useful purposes, but it remains to this day, on land, of minor importance. Windmills have long been abandoned for most industrial operations that can be continuously carried on in factories, and are now mostly employed for purposes connected with agriculture, as in pumping water for irrigation. Wind power seems never to have been extensively applied to the higher arts of manufacture, such as stone, wood, and metal working, and its most important service has been to grind grain. The limited application of windmills is largely due to the irregular and intermittent character of the power which they furnish and to the large investment necessary for large powers. It does not appear that windmills have ever exerted a marked influence toward the concentration of manufacturing operations in a few hands or in large establishments. The wind blows alike for all; the individual may use its energy at slight expense, and large capital finds in it but a small advantage. The most important use of wind power has ever been in the interests of commerce. How different the effect of the sailing vessel is from that of the steamship on the ocean carrying trades can hardly escape attention. So long as sails move the cargoes, ships are mostly of moderate size, and many are owned by persons of small capital. As steam becomes the motive power, ships increase enormously in size, great corporations become their owners, and the individual ocean carrier disappears.

Water powers vary much in their influence on the conditions under which manufactures are carried on. In mountainous countries, where there are many small, swift streams, the small manufacturer usually finds cheap power, and the relative advantage of large works is reduced. In parts of France, Switzerland, and the United States the frequency of small industries using water power illustrates the tendency of their surroundings. Where the country is moderately flat and the rivers large or of slow currents, the capital required for the development of water power is great, the energy available at a single point is also great, and large works are the natural result.

The tendency of great water powers to concentrate the control of industry in a few hands is counteracted to some extent by the varying amounts of such power at different times of the year. This variation of available water power from a fixed investment makes its actual cost more nearly that of the animal power which it is intended to replace. All the rivers of the globe could never concentrate in factories more than a small part of the world's manufacturing industries.

The development of steam power, however, has been very largely the cause of the extensive growth of the factory system. With fuel equal in value to the wages of a workman for a single day, a modern steam plant delivers during ten hours as much energy as the muscles of a thousand stalwart labourers. This cheap power has operated to move the loom from the workman's house to the mill, to stop the foot-power lathe, to close the small shop, and to develop industrial works on an enormous scale.

Each unit of steam power increases rapidly in cost as the capacity for its development is reduced. The steam

equipment to supply power for ten weavers, compared with that to furnish power to a thousand weavers, costs several times as much per man, the relative expense for fuel is easily three or four times greater, and the proportionate charge for the labour of operation is as much as ten times greater. When the cost of steam power for only one workman is compared with that for each of a thousand men, the difference against the former is found to be prohibitive. Since the first general introduction of steam power almost all the important improvements in equipment have tended to cheapen power for the large user, and little has been done to make it available for the very small user. So far as can now be seen, the tendency of steam power must continue in the future, as in the past, toward the concentration of manufactures in large works where great capital is necessary and many men are employed. That steam equipment is often used in comparatively small shops simply shows that in some cases the advantages of such shops in other directions offset their disadvantage in the matter of cost of power.

Electric motors, though they do not develop mechanical energy by chemical combinations, as does the steam plant, are exerting notable effects on manufacturing industries. The influence of electric motors is largely due to the ease and economy with which they distribute mechanical energy that has been otherwise developed. They tend to reduce the cost of power both in very large works and to very small consumers. In large works the electric methods of power distribution and control are more economical than any previously in use. To the very small power user, drawing energy from public electric supply systems, electric motors of very moderate first cost furnish power for less attention, less skill, and less cost than previously available in any other way.

The change effected by the electric motor in the cost of power is proportionately much larger and more material for the small than for the large consumer. Hence, the tendency of electric power is to create many small industries rather than to concentrate manufactures in a few large works. In the larger towns and cities of the United States many thousand horse-power of electric energy are distributed to small motors, each of which makes possible the employment of a few operatives in some line of manufacture. Water power is being electrically distributed at points on the Continent of Europe among scattered communities of individual workmen, so that they are able to continue as independent producers.

While electric motors thus tend to counteract, to some extent, the prevailing tendency to the concentration of manufacturing industry, it seems that their effect in this direction must be rather limited in extent. The main reason for this limitation is the cost of electric energy to the small consumer. This cost, though less than that of most other powers in small amounts, is nevertheless much larger than that of steam power in large plants. Thus, while the cost of fuel to deliver the energy that may be exerted by, say, a thousand men, during a day of ten hours, is the price of only one man's labour, this same amount, expended for electric energy at common rates, will purchase the equivalent of the muscular exertion of only forty men during ten hours, and it does not appear that there is any way to greatly lower the cost of electric power to the small consumer below present rates. Electric energy is first derived from mechanical motion, generated by falling water or chemical action, and the processes of transformation and distribution all involve expensive equipments and operations. Then, too, the small consumer of electric power cannot generate it for himself, but must buy from those who sell it at a profit.

Next in present importance to the steam plant, in the development of mechanical power from chemical action, comes the gas engine. The main advantages of this over the steam plant are that it requires no boiler and consumes fuel of less heating power for equal mechanical output. As a partial offset to its advantages, however, the

gas engine, as its name implies, is limited to gaseous fuel. It now seems certain that gas equipments will effect some reduction of the cost of power in large works over the lowest possible with steam plants, but this reduction does not promise to be very large. By far the most important and extensive applications of gas engines have thus far been with small manufacturers and consumers, though electric motors are much better adapted by their construction and nature for very small powers than are gas engines. But a point in capacity is soon reached to which gas engine construction is well suited and at which the engine usually offers a materially cheaper power than does the electric motor.

As might be expected from these facts, gas engines are usually applied in sizes larger than those most common for electric motors, but far smaller than those necessary in large works. Considered as to their influence on the conditions of manufacturing industries, gas engines have been a material aid to shops of moderate size, have done but little toward the building up of very large works, and have offered slight help to the very small or individual producers. An important limitation of the gas engine is its dependence on public gas supplies, except for comparatively large works. A very large plant may operate its own gas producers, but such an equipment would be prohibitive to the great majority of gas engine users. The price of gas from the public supply is thus an important factor in the cost of power.

With the view of avoiding some of the limitations that attach to gas engines, as to the limited service areas and cost of gas supplies, oil engines have been developed. Such engines are of two classes, one using the volatile oils from petroleum, and the other those of high flashing points. Gasolene is the most common fuel for the former class of engine, and kerosene for the latter. Development of these engines has thus far been limited to comparatively small sizes, and their effect on industry is to lower the cost of power for small manufacturers. Either class of oil engine consumes fuel of about equal value for the same production of power, the kerosene or gasolene for a small engine costing nearly five times as much as the fuel in a large steam plant to do equivalent work. So far as the outlay for fuel is concerned the oil engine puts small manufacturers in a much more favourable position than does any other power generator.

There are, however, important difficulties that operate against the general use of gasolene engines. So inflammable is gasolene that it must usually be kept in tanks outside of the buildings in which the engines are used. This extra risk of fire or explosion from gasolene relates to persons as well as property, and materially limits its use in engines by small or individual manufacturers with whom skill in operation is necessarily limited. Engines using the less volatile petroleum oils, such as kerosene, or still heavier ones, are not objects of extra risk. The heavy oil is stored in a small iron tank on the engine that holds a supply for many hours. These "heavy-oil" engines require a minimum of attention, may be had in very small sizes, are already largely used by small manufacturers, and constitute an important factor against the concentration of industry.

THE "POM-POM"

A NEW ELEMENT IN WARFARE

By Captain E. L. Zalinski, U. S. A., Retired

BATTLE OF ZAND RIVER, SOUTH AFRICA. A "POM-POM" SHELLING A PARTY OF BOERS AT 1800 YARDS

THE accounts of the South African War always included some accounts of the effects of the fire of the so-called "pom-pom." This, to the majority of readers, even those who were of the military profession, was obscure, and it was not known just what was referred to. It may be of some interest, therefore, to state briefly what a "pom-pom" is, and tell the story of its invention and introduction into use. This is all the more interesting in that it refers to the introduction of a new element into warfare.

Briefly, the "pom-pom" is a one-pounder, automatic gun. It uses metallic cartridges similar to those used in small-arms, but of a calibre of 1½ inches, throwing a shell weighing one pound. The cartridges are placed in a looped belt, and this is attached to the gun. By a simple operation, one of the cartridges is inserted in the barrel and is fired by pulling the trigger. After this the force of recoil is utilised to continue the firing automatically as long as belts with cartridges are supplied. The automatic principle has been applied in calibres up to 14-pounders. A hopper has been used in the larger calibres, as it was found that the belt would not serve as well. There is no reason why it may not be applied in calibres as high as the 6-inch, except that of handling and supplying the heavy ammunition with sufficient rapidity

In the numerous small wars that Great Britain was conducting a few years ago, we often read of the machine gun being put out of action. They jammed, and the men serving them were cut down by the savage foe. In fact, so unreliable was the machine gun at that time that, when a paper on machine guns was being discussed at the United Service Institution, someone suggested that the troops should be armed with theatrical clubs, instead of the machine guns. But all these were hand-worked guns.

When a gun is operated by hand it can be loaded and fired only a certain number of rounds in a minute, the rapidity of fire depending upon the time occupied by the cartridges falling into position by gravity. A small percentage of cartridges hang fire. These explode in hand-worked guns while the breech is open and the cartridge is being withdrawn from the chamber. This is the fatal trouble that was obviated in the automatic gun. It is very obvious that if, with a hand-worked gun, the gunner, in a moment of excitement, turns the crank or handle a little faster than the cartridges will fall in, the gun will jam and be put out of action. And this is exactly what did happen, and it discredited all kinds of machine guns. When it was announced in the London *Times* that an American engineer had invented a firearm with a single barrel, which would load and fire itself by energy derived from the burning pow-

A "POM-POM," OR ONE-POUNDER MAXIM GUN

der, and also that, with a single barrel, the rapidity of fire was considerably greater than with the multiple barrels employed in the ordinary hand-worked machine guns, the statement was received with a certain amount of incredulity. It was too good to be true. However, the gun was on exhibition at the time, and the little workshop where it had been constructed was soon visited by the Prince of Wales, the Duke of Cambridge, and hundreds of other distinguished people, both lay and professional. It was found that the story was no idle tale, but that a great discovery had been made, marking a distinctly new epoch in firearms. The statement that a gun had been produced in which the recoil of the barrel and its attachment at the instant of firing was able to perform all the necessary functions of extracting the empty cartridge case, of opening the breech, cocking the hammer, bringing a new cartridge into position, thrusting it into the barrel, closing the breech, and pulling the trigger, was a statement received with doubt. But that all this had been actually accomplished was vouched for by the distinguished personages who witnessed the gun in operation. Others of improved model were then made in rapid succession. The first models were of a calibre for small-arms cartridges.

But also among the first guns made were a considerable number of one-pounders having a bore 1½ inches. The first guns of this lot fired at the rate of about 400 a minute. Certain alterations were made which reduced this speed to 300 a minute. Numbers of these guns were brought before the notice of various European and American nations. The Russians purchased a few; the French perhaps fifty; the Germans very large numbers; Americans (chiefly South Americans) two hundred odd; China and various other nations only a few each.

Attempts were made to get this gun into the British service, but it was objected to on the ground that the projectile was unnecessarily large to kill a man and not large enough to be considered a piece of artillery. It was stated that an entire battery of these guns could be quickly put out of action by a single piece of field artillery, and that there was no place for them in either service. Had it been stated previous to the South African War that a British field battery of artillery could be put out of action by a single one-pounder in the hands of half a dozen farmers, the state-

ment would have been regarded as ridiculous,—quite as ridiculous as the statement would at one time have been considered that the little American yacht *Gloucester*, commanded by Wainwright, could destroy two Spanish torpedo-boat destroyers at Santiago. There is no question that a single piece of field artillery would stand a very good chance of putting a one-pounder Maxim automatic gun out of action, on a perfectly level field, with no cover. But the Boer did not fight these guns in that way. It was only after the beginning of the Boer War, when the "pom-pom" had demonstrated its practical value, that the British Government began to realise how important an element had been introduced into warfare in the field. They at once ordered Messrs. Vickers, Sons & Maxim, Ltd., of Sheffield, to turn out as many of these guns as possible, giving them practically an unlimited order.

A quantity of these one-pounder guns were made for the Italian Government about ten years ago, but they exchanged them for 6-pounders. They next passed into the hands of the Boers, who purchased a large number of rounds of ammunition and started a little factory of their own at Johannesburg for the manufacture of both guns and ammunition. Thus they secured the use of this formidable weapon, and were the first demonstrators of its value in actual warfare.

When the British troops had secured a lodgment on the top of Spion Kop, they found one of these Maxim guns, which the soldiers named the "pom-pom," secreted somewhere within 2000 or 3000 yards. The British were completely unable to locate it, as smokeless powder was used; but the projectiles continued to burst among them, and not only produced a demoralising effect, but also did a great deal of actual damage. At one of the battles on the Modder River, a battery of artillery went into action, firing at an invisible foe. But the Boers had located their pom-pom somewhere within easy range, and, as they fired only about five shots at a time, and, as the cartridges were charged with smokeless powder, the British were quite unable to locate the gun, and were finally compelled to retire. At other battles in South Africa as many as six Maxim automatic guns of rifle calibre have been put out of action by a single pom-pom. This was due largely to the superior range of the latter and the ability to locate the striking points by the smoke of the bursting shell.

The wonderful and unexpected success of these guns in the South African War was due, in a large measure, to the peculiar tactics employed by the Boers, who did not come out in the open to fight. With a piece of ordinary field artillery the charge is such that sufficient dust and gas are blown into the air to make the gun visible even when using smokeless powder. It is difficult, also, to conceal a piece of artillery, with its horses and other accessories. Moreover, a piece of artillery recoils and has to be brought back into position and resighted after each discharge. This, however, is being somewhat minimised by improved non-recoil carriages, which are now introduced.

With a pom-pom the recoil is all taken up inside of a stationary casing, and but little of its force tends to displace the carriage. The gun does not, therefore, budge when it is firing. The gunner takes deliberate aim, guessing at the range. He fires about five shots, which can be done by holding the trigger in the "pull" position for about one second. As soon as the projectiles explode, he is able to observe exactly where he is hitting, and quickly readjusts his sights. After a few trials he is able to explode the projectiles on the exact spot required, and, as the recoil does not disturb the position of the gun, he can go on firing as long as he wishes.

It is stated that the Boers seldom fired more than twelve shots at a time without waiting for the gas to blow away. If they fired more, their position might be discovered by a cloud of gas and dust, sufficient to make them visible. The water jacket used in the Maxim system to cool the barrel has been

thought an objection, but, as a matter of fact, it is seldom found necessary to change or renew the water; indeed, the guns are not fired with sufficient rapidity to become so heated as to boil the water at all. It is now admitted that one of the chief surprises of the South African War was the pom-pom, and British officers very soon found that it was the most troublesome piece of artillery with which they had to contend.

It is said that all modern improvements greatly increase the cost of war. This is true in a very marked degree with the 1½-inch Maxim gun. The cartridges cost about 6s. apiece, and it is possible to fire as many as 300 of these in a minute; in other words, these guns may, for each minute they are being fired, consume about £90 worth of ammunition.

The British Government has ordered from the makers, up to the present, several millions of these cartridges. From this some idea can be formed of the expense of conducting war on modern lines, as the rapidity of fire possible, of all guns, large and small, is being constantly enhanced.

The Maxim automatic gun, using rifle ammunition, fires between 600 and 700 rounds a minute, and, where the range is very long, the gunner is quite unable to ascertain where his projectiles are striking. He may fire a thousand rounds, and not one of them may hit the target on account of some error in judging the distance. But with the pom-pom the point of striking is clearly indicated. The projectiles explode on striking, making a cloud of dust and smoke. The gun itself thus acts as a most admirable range-finder, and this is a very great advantage.

When the machine gun practically first made its appearance in the Gatling 10-barrel design, it weighed about 1000 pounds. The projectiles were lead, and weighed rather less than an ounce each. The pom-pom weighs about 500 pounds, has only one barrel, and the projectiles weigh rather more than a pound each. It will, therefore, be seen that there is a very great difference between the efficiency of the old hand-worked gun and the modern automatic gun.

It is too much to claim that finality has already been attained in this field. But the development thus far has been most remarkable.

MACHINERY IN AGRICULTURE

By George Ethelbert Walsh

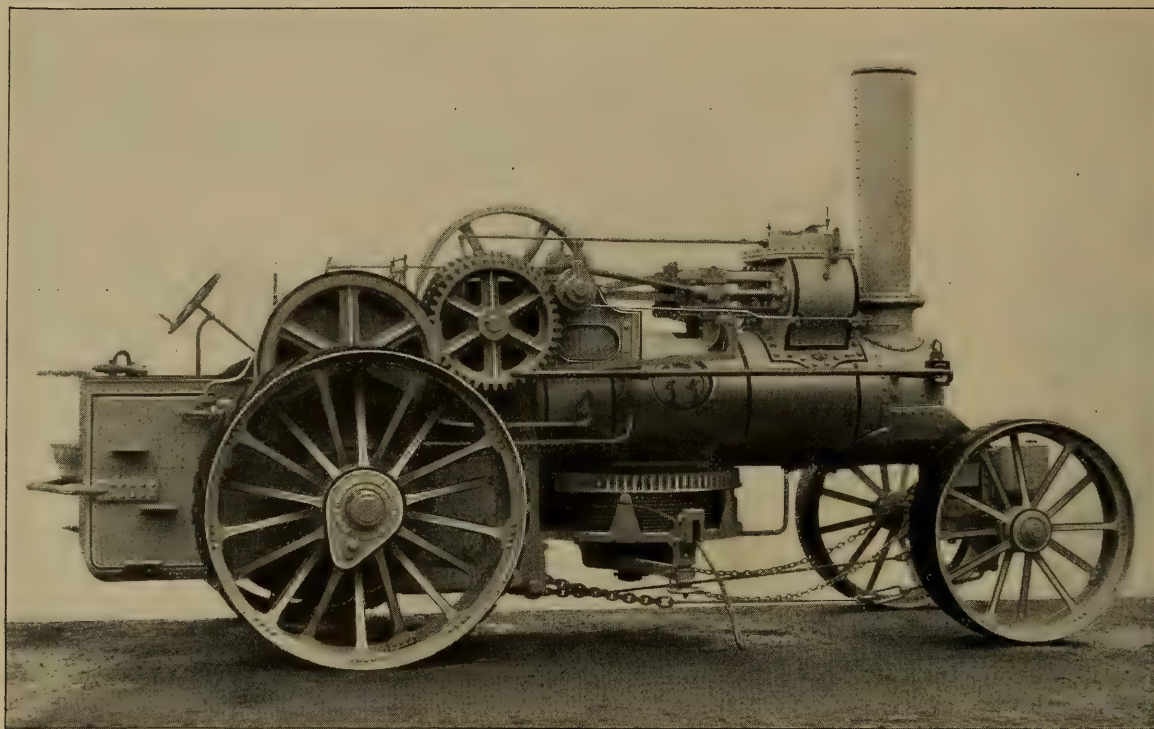
THE modern, up-to-date farmer is as much a machinist and skilled mechanic as many who labour in shop and forge. Inventions have revolutionised farming so radically in the past half century that it is as essential for the agriculturist to be familiar with the practical details of handling and caring for machinery as it is for him to understand the best methods of cultivating plants or the rotation of crops. Not even in the manufacturing industries have more inventions been made to simplify work than in farming life.

So much is done by machinery on a farm of to-day that it would be difficult to imagine how one got along before the era of practical invention. Indeed, in the production of some crops machinery forms such a constant and conspicuous feature that one could almost say that they are manufactured instead of being raised. The soil may primarily furnish the conditions essential to plant growth, but machinery supplies it with the necessary fertilising elements, tills it so that it is ready for the seed, changes its chemical and mechanical conditions for the better, sows it with the seed, cultivates it through the period of growth, harvests the crops when mature, and finally turns the land over again for another crop. When man toiled in the fields and planted and reaped by hand, he raised his crops by the sweat of his brow; but to-day he more often rides on his machinery and lets hands of iron and steel do the planting and reaping. He manufactures his crop of grain almost as truly as another manufactures linen, cloth, or silk.

Forming such a conspicuous part of the farming of to-day, machinery and invention have naturally affected economics to an extent few appreciate. Farming is by all odds the great industry of America for example. It furnishes employment to the greatest number of men; it supplies the food and raw material for scores of other departments of human endeavour; it adds yearly hundreds of millions to the national wealth, and it greases the wheels of commerce from one end of the country to the other. Without it railways would go into bankruptcy, and lines of coast and inland steamers would fall into disuse through lack of freight to carry; in short, the commerce of seventy millions of people would be paralysed, and there would be a panic and famine in the land that would eclipse anything that has ever afflicted India.

Agriculture has developed at a marvellous rate in the last half century because of the possibilities opened to it by the inventive genius of the times. The growth of the two are co-extensive.

AN ALLEGED STEAM PLOUGH OF LONG AGO. FROM AN OLD GERMAN PRINT



A STEAM PLOUGHING ENGINE BUILT BY MESSRS. JOHN FOWLER & CO., LTD., LEEDS, ENGLAND

AN EIGHT-FURROW TURNOVER STEAM PLOUGH, MADE BY MESSRS JOHN FOWLER & CO., LTD.

One cannot trace the inventions of the age without encountering the marvellous development of a new agriculture, which has done more for the human race than all the gold, silver, and iron mines combined. In farming on a large scale the great difficulty has always been that the crops ripened in the short summer season, and if they were not harvested within a brief time the waste would be enormous. Farm work in the harvesting season was thus rushed so that sufficient labour could rarely be obtained, and double wages had frequently to be offered to induce workmen to hurry. A farmer owning hundreds of acres

might thus be so handicapped for the lack of sufficient help that he could not cultivate more than one-quarter of his domain. If, by superhuman efforts, he should succeed in cultivating and sowing the whole farm, he would more than likely lose half the crop through waste in harvest time. The day of the big farm could not come until these conditions were revolutionised by farm machinery. With the coming of the great harvesters, the planters, cultivators, and scores of other farm mechanism, there was an opportunity to double and quadruple the crops, and the farms gradually increased from ten and twenty acres to one and two hundred.

The McCormick reaper saved immense sums in a single year to the farmers of the United States alone, and other machinery has saved like big sums to that country's producers through its ability to lessen the farm work and increase the output of each acre. The power of increasing the size of crops has, in the United States, developed at a much faster pace than the multiplication of population, and from an agricultural nation barely able to raise enough for home consumption, America has grown into the greatest exporter of farm products in the world. This doubling and quadrupling of these products through the improvement of machinery continues to-day, and on the great farms of the American Northwest new inventions are annually improving and simplifying past conditions. Within the past few years the great traction engines that have been introduced on the California wheat fields have enabled the farmers to raise wheat at much less per bushel than ever before. The scarcity of labourers at harvest time annually made the problem on the immense grain fields difficult of solution, and it was not until the modern traction engines were built that the harvesting could proceed with anything like success.

These engines do the ploughing, cultivating, seeding, and harvesting on farms of a thousand acres in extent in much less time than a whole army of employees could do the work on a farm of half the acreage. The largest of these traction engines are of fifty horse-power, and, with driving wheels sixty inches in diameter and flanges of generous width, they can travel over the uneven surface of the grain fields, crossing ditches and low places, and ascending the sides of steep hills, with as much apparent ease as a locomotive rolls along on its steel rails. Such powerful traction engines, or "automobiles," as they are commonly called by the American farmers, are capable of dragging behind them sixteen ten-inch ploughs, four six-foot harrows, and a drill and seeder. The land is thus ploughed, drilled, and seeded all at one time. From fifty to seventy-five acres of virgin soil can thus be ploughed and planted in a single day.

A WOODEN PLOUGH OF THE FAR EAST

When the harvesting season comes, the engines are again brought into service, and the fields that would ordinarily defy the best efforts of an army of workmen are garnered quickly and easily. The giant harvester is hitched to the traction engine in place of the ploughs

REAPING WITH SICKLES IN ALGERIA

and harrows, and cuts, binds, and stacks the golden wheat from seventy-five acres in a single day. The cutters are 26 feet wide, and they make a clean swath across the field. Some of them thresh, clean, and sack the wheat as fast as it is cut and bound. Other traction engines follow to gather up the sacked wheat, and whole train loads of it thus move across the fields to the granaries or railways ready to convey it to the grain elevators of the seaboard or interior. These great mechanical grain reapers and harvesters represent probably the highest achievement of scientific farming with machinery, and have enormously cheapened the cost of producing wheat.

Before the building of the reaper the tillers of the soil found their life trying, and the returns for their labour were slight indeed. The "Great West" of the United States would never have been conquered had not the mower and self-binding harvester come into existence. To-day nearly half a million of these machines are required to reap the grain harvests of the country. The annual output of the mowers and harvesters amounts to nearly one-fifth of a million, and they are sold in all parts of the world, but in no country are they used so extensively as in America. Even the great wheat fields of the Argentine Republic, in South America, use only a small fraction of the number of mowers and harvesters that the farmers of the United States employ on the same extent of territory.

And yet it is not much more than half a century since the invention and building of the first practical harvester and reaper. At the beginning of the century now just expiring, the Royal Agricultural Society of Great Britain offered a prize for the production of a successful reaper; but for forty years this offer was kept open without attracting any successful inventor. Several machines were constructed, and were exhibited at various times, but none of them appeared to give sufficient evidence of practical value to attract more than passing notice. The invention of the McCormick reaper, in 1831, by Cyrus H. McCormick, in the United States, was the beginning of all subsequent reapers, and the elements of that early type have been incorporated into every machine built since then. New inven-

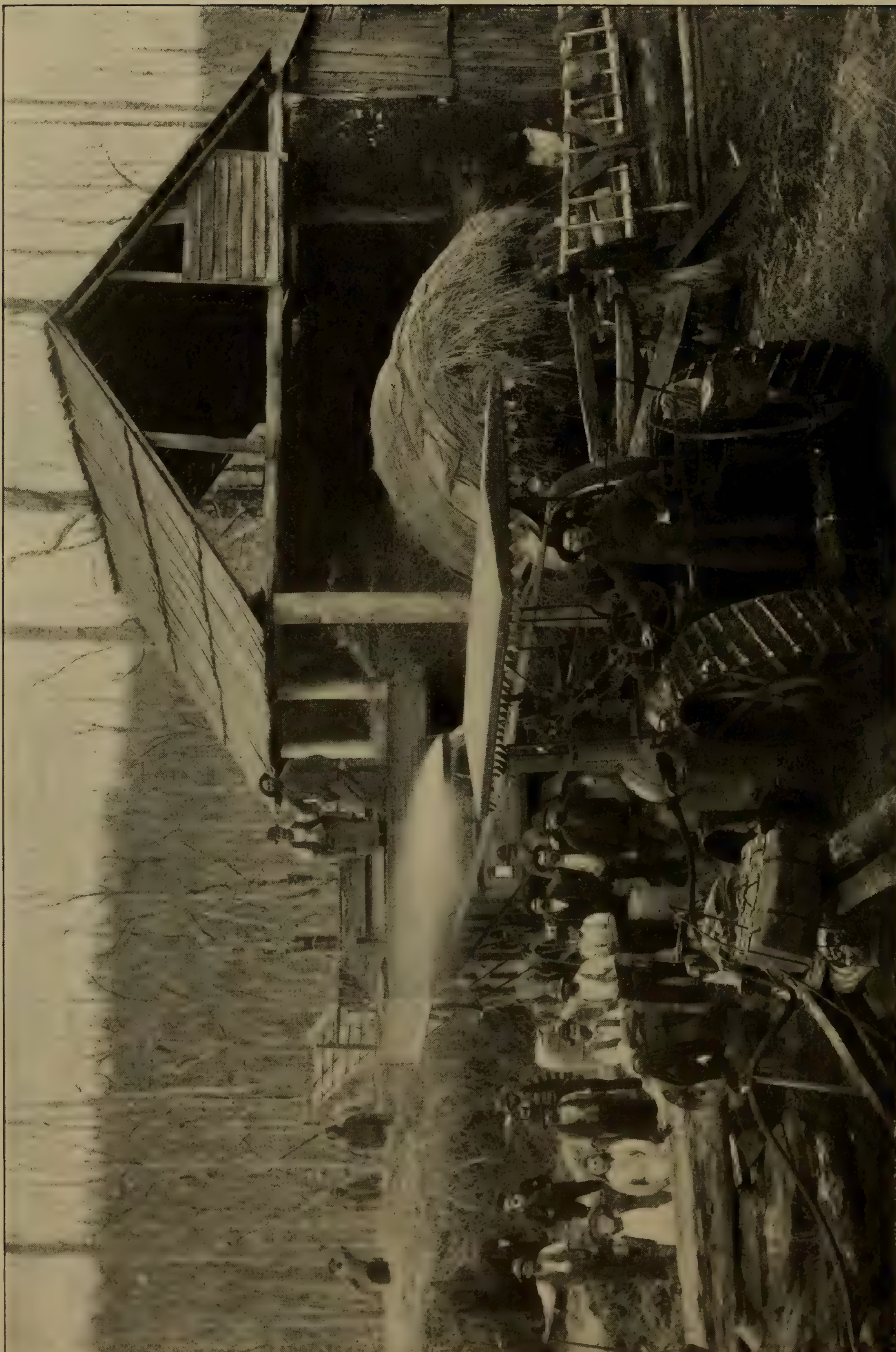
tions have been added to the original machine, and it has passed through an evolution that makes it look like a very different thing from its prototype. Countless inventors have tried every other form of mechanism to take the place of that found in the McCormick reaper and covered by patents, but they have all failed to make any wholly satisfactory substitute for the original system.

The first McCormick reaper was successfully operated on the farm of John Steele, near Steele's tavern, Virginia, in the summer of 1831. Two years later the Hussey, somewhat similar to the McCormick, was operated on the same field. Up to 1845 these two machines were operated in competitions all over the United States. About this time McCormick began to make those new improvements and inventions in

REAPING WITH A M'CORMICK REAPER IN SOUTHEASTERN RUSSIA

his machine which have given it worldwide fame. The raker seat attachment was one of the first improvements by which the raker could be carried upon the reaper, and when sufficient grain had accumulated on the platform, it could be raked off on the ground to form a bundle. This distributed the grain in even bundles throughout the field, but not automatically, as a man had to do it from his seat back of the driver. In 1851 the judges at the World's Fair at London gave the McCormick reaper a special medal for reapers, and in their report said that the whole cost of the Exposition was well paid for by this machine if introduced in Great Britain. In France the value of the reaper was likewise quickly recognised, and the inventor was decorated as an officer of the Legion of Honour for "having done more for the cause of agriculture than any other living man." In one year the McCormick reaper was said to have saved $40,000,000, or about £8,000,000, to the farmers of the United States.

Yet no man had more difficulty in introducing his machines than that pioneer inventor of agricultural implements. Farmers everywhere were slow to accept it, and manufacturers were unwilling to undertake its manufacture. Even after the value of the machine had been demonstrated, everyone seemed to fear that it would break down on rocky and uneven fields, and the inventor had to demonstrate in person to the farmers the practicability of the reapers, and then even guarantee them before money could be obtained. Through all these trying discouragements the persistent inventor passed before he saw any rewards for the work that he had spent half a lifetime in perfecting. The ultimate triumph of the inventor may be



A FIELD SCENE SHOWING AN AGRICULTURAL ENGINE BUILT BY THE FRICK COMPANY, WAYNESBORO PA., U. S. A.

sufficient reward for his labours and discouragements, but those who would begrudge him the wealth that he subsequently made from his invention should consider some of the difficulties and obstacles he had to overcome in the beginning.

The growth of grass and grain cutting machines began in 1831, and in 1840 there were only three machines operated in the United States. By another decade, however, there were 3000 produced and in use, and in 1860 the output had increased to 20,000 machines annually, employing regularly over 2000 people in their manufacture. In another ten years the growth had increased to 60,000 machines, and by 1885, when the automatic cord binder was invented, the manufacture of reapers, mowers, and binders had taken gigantic strides. The industry had increased so that more than 30,000 people were employed in manufacturing reapers, mowers, and self-binding harvesters. Altogether, the output from the three original machines had grown to over 250,000 for that year. With continued improvements in the machines the demand for them increased, and by 1890 the export trade in them began to assume considerable proportions. As far back as 1880 over 800 self-binding harvesters were exported, and 3000 mowers and reapers. The popularity of the American machines in Europe increased in rapid proportions, and the factories were kept busy in supplying the demand. In 1890 the South American wheat-growing countries began to use American harvesting and mowing machines, and the annual export of mowers, reapers, and self-binders to Argentine Republic, Paraguay, and Uruguay amounted to 3000 on the average. Since 1895 these exports have largely increased. Another quarter of the globe that buys agricultural machinery on a large scale is the colonies of Australia and New Zealand, while much goes to the grain regions along the banks of the Red Sea and the Volga, in Russia, and to different parts of France, Norway, Sweden, Germany and Scotland.

HARVESTING MACHINE MADE BY THE DEERING HARVESTER COMPANY, CHICAGO, ILL., U. S. A.

The McCormick patents expired in 1848, and that was the beginning of the great manufacturing industry in various places. Many concerns started in to manufacture harvesting machines. Up to 1858 the self-raking reaper was in general use, and four men had to follow behind it to bind the grain into bundles. In that year a harvester was invented which carried two men on a platform where they bound the grain as it was raked up, and it was supposed that they could do the work of four men following in the field after the old type of harvester. By 1865 this type of harvester was pretty generally in use.

From this the harvester developed to the self-binding attachment by which the work was done automatically. As

THRESHING MACHINERY AND AGRICULTURAL ENGINE BUILT BY MESSRS. MARSHALL, SONS & CO., LTD., GAINSBOROUGH, ENGLAND

A MAIZE SHELLING MACHINE BUILT BY MESSRS. RICHARD GARRETT & SONS, LTD., LEISTON, ENGLAND

early as 1851 patents for binding attachments were filed, but no machine was equipped with a practical attachment of this nature until 1860. Wire was used for this work, and it did not prove profitable enough to continue it for more than a few years. Half a dozen different inventors were at work on binding attachments, and the new manufacturing companies of harvesting machines were also trying to solve the knotty problem. All of these early workers in the field used wire for their binding material, but in 1870 so much opposition to wire had been made that it was abandoned and cord was substituted for it.

The first successful automatic cord binder in the United States was built and in operation in the summer of 1874, and was the work of Marquis L. Gorham, of Rockford, Illinois. His harvester was of the McCormick type, and contained all of the latest improvements of this, with the binding attachment adjusted so that bundles of grain were carefully tied of equal size with cord. The plan adopted by this inventor is practically the same as that in general use to-day on most of the reapers. The new California reapers are further improvements upon this early self-binder, but they are adapted only to very dry climates, and would be of little use outside of California. They cut, bind, thresh, and sack the grain by a single operation, and when drawn across the field by a traction engine, they make a clean harvest of the wheat. These machines are not built in any great number, and perhaps not more than half a hundred are sold a year. For completeness of mechanical service in climates and countries to which they are adapted they have no superior, and they represent the very highest achievement in modern harvesting machines.

AN ELECTRICALLY DRIVEN PLOUGH, SHOWN AT THE RECENT PARIS EXHIBITION BY THE BRITISH SCHUCKERT ELECTRIC CO., LTD., LONDON

The development or evolution of the harvester has naturally usurped first place in agricultural machinery, for it has by all odds had a more important economic bearing on the farming industries of a country than any other implement invented. But scores of other farm machines have, in the last quarter of a century, multiplied the products of farms and lessened the work of the farmer. The consuming public has received the direct benefit of all these inventions in the cheaper products of the

A REAPING MACHINE MADE BY THE WALTER A. WOOD MOWING AND REAPING MACHINE CO., HOOSICK FALLS, NEW YORK, U. S. A.

A HARVESTER AND BINDER MADE BY THE WALTER A. WOOD COMPANY

soil. The potato-planters and diggers have just as surely benefited the consumer as the great harvesters have made it possible for half the world to eat wheat instead of rice, rye, or other less strengthening cereals. The horse-rakes and hay-loaders have cheapened the products of the grass fields so that city dwellers can enjoy the luxury of horses at far less expense than if old-fashioned machines and methods were still in vogue. The incubator and brooder have multiplied the annual harvest of chickens by ten. The slaughtering machines for hogs, the separators and patent rural populations would find all their time and labour engaged in raising sufficient for home consumption. This reduction of income from farm exports would fall heavily upon merchants, transportation companies, and many minor concerns. The change would hardly be conceivable.

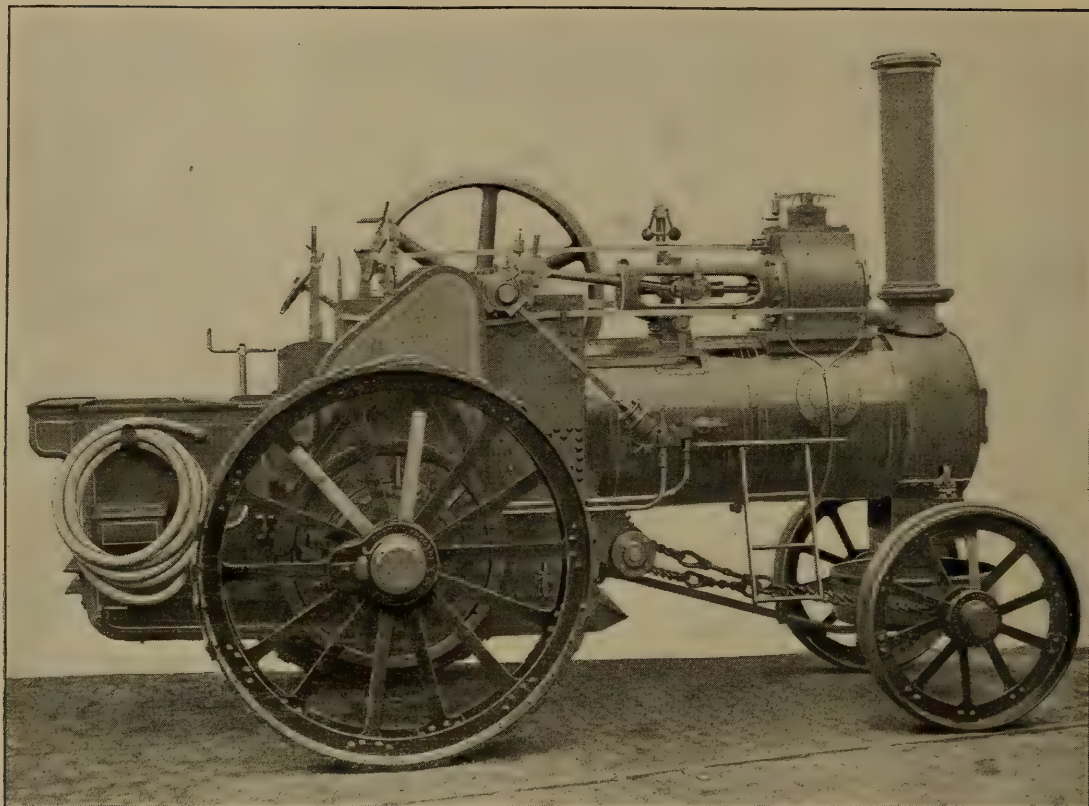
In addition to all the farm industries touched by modern implements and machinery, attention should be directed to the vast manufacturing world that has been created by these labour-saving products for the farmer. Enormous sums are invested in plants for making

A STRAW TRUSSER MADE BY MESSRS. RICHARD HORNSBY & SONS, LTD., GRANTHAM, ENGLAND

churners of the dairy farm, the berry-pickers of the fruit farm, and the corn-huskers of the great corn districts have all touched modern life, and made the cost of food and raiment cheaper and more abundant.

Without modern agricultural machinery our harvests would be so unsuited to our population and method of living that our income would be more than quartered. The rich as well as the poor would feel the change. In the great farming countries, like the United States, farm exports would cease, and

the machinery. Again referring to the United States, as has been done repeatedly in this article simply because of the enormous interests which that country has in farming products, it may be stated that the annual output of its different establishments for making agricultural machinery is valued at tens of millions of dollars. More than two hundred thousand employees are provided with regular work the year round by the factories that make the implements and machinery, and nearly as many more are indirectly engaged in selling, trans-



AN AGRICULTURAL ENGINE BUILT BY MESSRS. RUSHTON, PROCTOR & CO., LTD., LINCOLN, ENGLAND

porting, and shipping the products to their final destination. The vast and complicated net-work of business that is thus set in motion by the demand of the farmers for harvesting and planting machines is hardly surpassed by any other single industry in any country. It touches the farmer and consumer at one end, and feeds and gives employment to the inventor and mechanic at the other. It furnishes profitable investments for the capitalists, produces material for the transportation companies, builds mills and factories, opens a new field for the products of the iron and steel mills, and provides lucrative employment to an army of clerks, salesmen, and merchants.

THE DEVELOPMENT OF THE GAS ENGINE

By Robert S. Ball, Jr., A. M. Inst. C. E.

LIKE the steam-engine, the motor operated by the explosive force of mixtures of inflammable gases made its first appearance in a form widely different from the present engine with which we are so familiar. We are told that the idea of utilising the force of explosion for the propulsion of a motor suggested itself to the mind of a mechanician in the latter part of the seventeenth century. His first experiments were made with the products of combustion of gunpowder ignited in a cylinder, and later the idea was taken up by other experimenters with indifferent success.

However crude and incomplete these first trials were, they opened a door to investigation, and the succeeding engineers, to whose labour we owe so much, forged and shaped, by a gradual process of evolution, the engine of to-day, which has become such a valuable assistance in the production of cheap power. Probably the later development was very largely due to the improvements in shop machinery and the more universal manufacture of a cheap gas, which enabled those of later years to turn their ideas into practical channels. In those early years, however, inventive talent was divided between the gas motor and its powerful rival, the steam-engine. A few years before Robert Street had taken out his patent upon a gas engine, James Watt had astonished the mechanical world by his marked improvement upon the crudities of earlier steam-engine inventors, and the two machines were thus placed neck to neck in the race for commercial recognition.

Besides the inherent defects in the gas engines of earlier times, the application of the motor to industrial purposes must have been arrested to a great extent by economic conditions prevailing. Illuminating gas had not come into general use. The product of the few gas works then existing was inferior and costly, and the great natural gas fields of new countries were still unopened. On the other hand, the steam-engine had established itself at mines and manufactories where fuel was cheap. It consumed waste from the dump heaps, and in return gave forth useful work, and, though uneconomical and inefficient, it was welcomed, studied, and improved. It was supplied with gas,—for steam is a gas, though an imperfect gas,—by the boiler close at hand, while the gas engine proper had no convenient and cheap source from which to draw the working fluid necessary for its operation. It is not surprising, therefore, that for many years it made slow progress. But at length the attention of inventors was drawn to its possibilities, and under the genius of contributing mechanicians many inherent defects were removed. Assisted by cheap gas and the demand which sprang up for small motors, it rose into favour with astonishing rapidity. At first small units were turned out to supply a demand which, for a long time, was confined to engines of a few horse-power. Gradually the size of the engines was increased to very large units, which have shown an increase in mechanical efficiency over the smaller sizes. Friction and radiation losses are less with the large sizes, as in the steam-engine; but it was not known until proved by the results of actual tests that the large

gas engine justified its existence by showing an unlooked-for efficiency.

We find among the work of the early gas engine inventors traces of ideas analogous to those which assisted in the development of the steam-engines. Thus, in the first quarter of the nineteenth century patents were granted covering a plan by which gas was employed to produce a vacuum in a cylinder. The gas was passed into the cylinder with air, and then ignited; water was then introduced, which condensed the mixture, and the resulting vacuum allowed the piston to be acted upon by the atmospheric pressure without. The steam-engine of Newcomen was also actuated by atmospheric pressure, but the vacuum was obtained by the condensation of steam instead of gases. Afterwards this idea was abandoned in both forms of motor, and the employment of steam under pressure in the one case, and gaseous products of combustion, also under pressure, in the other, superseded the very inefficient and wasteful principles upon which the earlier types of motors were worked.

Perhaps the most striking point in comparing the older forms of engine with those of to-day would be their relative sizes and consequent weights for equal powers. As the power of any motor is measured by foot-pounds exerted in a unit of time, and as these foot-pounds are dependent upon the mean pressure acting on the piston, multiplied by the feet through which the piston travels in the given unit of time, it is clear that an alteration in one or other of these quantities implies a corresponding alteration in the power of the motor. When we find a small gas engine of to-day rated seemingly out of proportion to its dimensions, we must look for the reason in the figures which represent mean pressure on the piston and piston speed.

We find, in tracing through the pages of history of the gas engine, that both the piston speed and the mean pressure acting upon the piston have been increased; or, to state it in another way, the dimensions of the engines have been reduced for the same power. The high steam pressures and high piston speeds have worked similar changes in modern steam-engines, and the field formerly occupied by the slow-speed, low-pressure mill engine is now invaded to a considerable extent by the high-speed, high-pressure machine. While the increase in speed of gas engines no doubt has played a part in the development of the engine, augmented pressures have, to a far larger extent, been the cause of its commercial success. The initial pressure in the cylinder of a gas engine is due to the quality of the mixture of gas and air, and also to the density of the mixture before ignition. It was known for a long time that different mechanical mixtures of gas and air produced different intensities of pressure upon ignition, but it was only in recent years that the density of the mixture before ignition was increased by compression.

Many of the best authorities concur in the belief that this invention raised the gas engine out of the purely experimental stage and placed it in the class of commercially successful motors. Various plans were tried by which the mixture of gas and air was to be introduced into the cylinder under pressure. Independent pumps were first utilised, but, later, these were abandoned as needless encumbrances, and the work of compression was transferred directly to the engine cylinder. When the working cylinder was thus utilised as a compressor for preparing the charge of air and gas for ignition, it became necessary to assign separate strokes of the piston to the two functions of compression and ignition followed by expansion. Besides these two operations, the mixture had to be drawn into the cylinder, and the waste gases, too, had to be expelled at the proper time. These four operations, taken together, constituted a cycle, and the mechanism of the engine had to be designed to accomplish it with unfailing regularity. The difficulties of construction incident to these requirements were at length overcome, one by one, and the recurring successions of different operations within the cylinder comprising the well-known

cycle of Beau de Rochas has been accomplished by mechanisms no more complicated than many attachments designed for the purpose of increasing the efficiency of the steam-engine.

The economy of the gas engine is no longer questioned for certain purposes and in certain localities where favourable conditions exist. The engineer has brought it up to a high state of efficiency, which, however, does not necessarily imply that it is an economical motor in the commercial sense. It is, from the engineer's standpoint, a very efficient heat engine, for a very large percentage of the heat in the fuel is given back in the form of mechanical energy available for driving the machinery to which it is connected. The relative cost of gas and coal, and the kind of service to which the engine is to be put, are considerations which may decide the question in favour of the steam-engine or water-power, but the balance of economy is on the side of the gas engine in an ever-widening field.

The requirements to which a motor must conform to-day are more exacting than formerly, both in fuel economy and in speed regulation. This latter necessity never before assumed the importance that it has at the present time. The introduction of the dynamo, and the rapidly increasing demand for motors adapted to the driving of alternators in parallel, have been met by a high degree of excellence in the governing attachments on gas engines. Difficulties of a very obstinate nature had to be overcome to give the gas engine good speed regulation. The force of the explosion, occurring once during every two or more revolutions of the crank in single-cylinder engines, was smoothed by extra heavy fly-wheels. The governing mechanism has not departed to any extent from the well-known centrifugal principle used in steam-engine governing, but the methods by which the centrifugal action of the governor balls or weights operate to alter the speed of the gas engine are somewhat different from the cut-off or throttling mechanism used with steam valves. One method consists of allowing the engine to miss an explosion by the single expedient of cutting off the supply of explosive mixture. This is attended with all the disadvantages of coarse governing, for small fluctuations in speed exercise through the governor a somewhat violent change in the amount of energy imparted to the motor. Another system which has found practical acceptance is to alter the quality of the mixture by the regulation of the air and gas valves.

It is difficult by such a method to ensure that the impulse given to the engine by the varying quality of the explosive mixture shall be of the desired intensity. A heavy fly-wheel will allay, to some extent, the results of gauging the mixture inaccurately, but extra weight thus added is a poor expedient to adopt for the purpose of covering up the defects of regulating the admission. It is less a matter of uncertainty to vary the amount of mixed gases entering the cylinder than to tamper with the quality of the mixture through the movement of the governor. In engines worked on this principle the valve under control of the governor varies the supply of gases in the same manner as the throttle valve of a steam-engine regulates the supply of steam. The result is a varied compression or density at the time of ignition, and a proportionate impulse after explosion. These methods explain in a general way the up-to-date practice of gas-engine regulation, and the results obtained answer the exacting specifications of electrical engineers and others to whom close regulation is an essential requirement. It was at first supposed that the intense pressure at the moment of explosion, resulting in acceleration, would prevent the gas engine from seriously competing with the steam-engine. We have only to look at the engine market of to-day to see that these prophecies were not true. Many electric installations are operated satisfactorily by multiple-cylinder gas engines with perfect regularity and marked economy in working expenses.

The gas-engine manufacturer has less difficulty than he had fifteen years ago in satisfying the public of the superior-

ity of this class of motor. But while the average buyer is now more readily impressed with the advantages of the gas engine, he is correspondingly careful in selecting an engine adapted to his requirements. He is better informed concerning the good and bad points of those upon the market, and even without the services of an experienced engineer to guide him in his choice, he will display an accurate knowledge of the conditions and requirements pertaining to his special case. The demand thus created has reacted upon the manufacturers, with the effect of making them keenly alive to the public necessity for various types of engines designed to fill a variety of conditions of service. We thus find gas engines large and small, engines for natural, illuminating, or producer gas, engines with close regulating appliances, and also for those purposes, such as pumping, where close regulation is unimportant. Some are designed to display high efficiency at full load, while at other conditions of loading the efficiency is lost sight of; still another class sacrifice something of full-load efficiency for the benefit of raising the efficiency of partial loading, thus maintaining a high average when the engine is lightly loaded, as may often happen.

The most exacting duty which can be thrust upon any engine is, perhaps, seen in central station electric work. A tramway plant, for example, with a constantly fluctuating load, large amounts of which are suddenly thrown on or off with the starting and stopping of the cars, puts the engine to a severe test. The severity of the shocks thrown upon the machinery is much more intense in small installations where, with a few trams on the line, the starting or stopping of one throws on or off a large fraction of the total load. With direct-connected units, which are now associated with the best practice, the strains thus thrown upon the engine are very great. The governing mechanism is well tried under such conditions, and a very efficient appliance is necessary to prevent violent changes in the line voltage. Problems such as these have been satisfactorily solved by the gas-engine designer in recent years.

In generalising upon the subject of the relative claims of steam and gas engines for industrial purposes, the champions of each type of motor are sometimes content to centre the issue upon the question of their thermodynamic efficiency alone. It is, in fact, the only common ground upon which they can meet, for the prices of fuel, upon which the commercial efficiency depends, are inseparable from purely local conditions. It is true that the fuel used in both forms of engine is the same (with the important exception of natural gas now used in gas engines), and that though we are accustomed to the name "gas engine," used in contradistinction to other forms of heat engine, it is none the less a coal-consuming machine, which shares with all thermodynamic contrivances the usual wasteful features.

In making comparisons of this kind, we must, therefore, take a unit weight of coal or fuel, and ascertain how much of the thermal energy of this fuel is actually delivered in the form of mechanical energy at the shaft of the motor as measured by a brake applied at that point. By so doing we embrace all possible losses occurring during the transformation from one form of energy to another, and however interesting it may be to be able to assign certain fractions of the total loss to special parts of the transforming apparatus, it is quite irrelevant to our purpose, for when the commercial economy of the plant, as a whole, is under consideration, we are concerned only with the total loss of energy in the system.

The gas engine is generally placed at a disadvantage unless the foregoing considerations are regarded. It is quite customary to state the performance of a steam plant in so many pounds of coal per horse-power per hour. We often hear of gas engine power being expressed in cubic feet of gas, which would be valuable if the calorific value of the gas were always known. It would be equally indefinite to express the work of a steam-engine in so many horse-power per cubic feet of steam without

stating the pressure in pounds per square inch, and the percentage of moisture in the steam. Even if the work of both forms of motor were expressed in so many horse-power per pound of coal, it would not necessarily mean that they were placed upon the same basis for comparison. Some kinds of coal are better for steam making than others, and there is also a difference in the amount and quality of the gas to be obtained from coal of different quality and price.

Almost every steam plant is complete in itself; gas plants are not generally so. The coal is brought to the boiler room at the steam plant, but many gas engines receive the supply of gas from a distant source. The gas thus supplied is generally too rich for power purposes. A profit has to be paid to the manufacturer, and this expense is naturally charged against the gas engine when taking an estimate of its commercial value. Until recently this was the only possible source from which gas engines were supplied; but leaving out of the question the increasing usefulness of natural gas supply, we have a means for making a suitable gas from coal at the place of consumption. Water gas, generated by blowing steam over burning fuel, has been tried; also producer gas, which is manufactured in the same manner, except that air is used instead of steam. A combination of these two methods, known by the name of the inventor, Dowson, has been found very successful, and the gas made by his process possesses the essential properties of a motor gas, for though the initial capital outlay in a plant of this kind is somewhat more than with a steam boiler battery of equal power, the resulting economy is very marked, and decidedly advantageous for large powers.

The transmission of energy in the form of gas has lately been prominently before the engineering world, and there are many places in the American natural gas fields where the gas is carried through pipes for miles without serious loss from leakage or deposit. There seems to be little doubt that in localities favoured with such a natural supply the distribution of power by this method will be extended, and make it possible to furnish outlying districts with the advantages of cheap power.

Another important application of the gas engine has recently received much attention from engineers. The waste gases from blast furnaces have been used to make steam to drive the blowing engines, besides heating the stoves through which the air passes on its way to the tuyeres. Prof. Mayer has pointed out that as the steam-engine has a thermal efficiency of 10 per cent., while that of the gas engine is 20 to 25 per cent., a very considerable saving can be effected by the use of the gas engine for blowing. The gas engine has shared with all other forms of motor the unfavourable criticisms which are launched against new types of engines. In spite of this, it has steadily progressed in the estimation of engineers, and also of the public, and has been proved to be, for large powers, a less wasteful transformer of energy than its time-honoured steam rival.

Current Topics

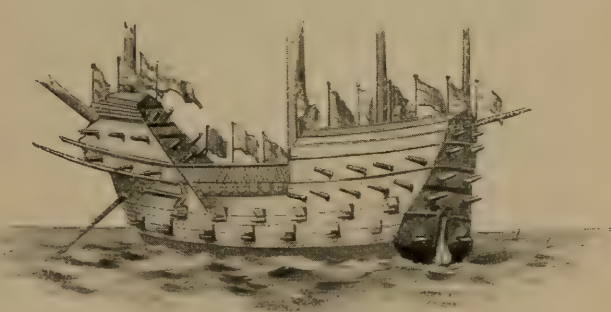
To the best-conceived enterprises, or mechanical contrivances, frequently occurs what one is perforce obliged to call "the unexpected," resulting possibly in disaster, but singularly enough, from the very nature of the thing, it cannot be anticipated or guarded against. The event, however, once having transpired, cause and effect may stand out in conspicuous evidence to condemn "the unexpected." Remote probabilities, or elements of chance combined, sometimes overreach the best judgment or foresight, and even that infallible hindsight stands dazed by what has occurred. It is not disasters entirely due to the elements that are now in mind, the sinking of a ship, for example, by a submerged iceberg, or any causes over which no human agency has control, but rather the matters of intelligent mechanical conception and supervision which should reasonably be exempt from any mishap. A case in point occurred a few years ago, when a 66-inch diameter by 30-foot oil tank of its own volition undertook to play the rôle of a surface condenser,—very much to its discomfiture. It was a new tank at the works of the manufacturer, undergoing the usual preliminary test, steam being introduced and maintained at twenty pounds. All leaks at rivets and seams were marked and rapidly calked. While this was in progress the whistle sounded the noon hour, followed by the usual stampede. The foreman in charge took the necessary precaution to close the steam supply valve.

It was a beautiful April noonday, but out of an almost solitary cloud came the proverbial April shower. It literally poured for less than a minute. "The unexpected" happened. Now it was not reasonable for the men in charge to anticipate what might, and actually did, happen, namely, the total collapse of the tank with a report that startled the community into the belief that a battery of boilers had exploded. Even had the play of the elements been foreseen, it was not reasonable to suppose that a sufficient vacuum would be created within the tank to produce collapse, since only a preliminary stage of the test had been reached. The shell was made of iron in seven sections, or rings, three-sixteenth of an inch thick, with dished heads, nine thirty-seconds thick. This thickness of plate, reinforced by circular seams, would presumably be sufficient to take care of the unbalanced atmospheric pressure due to any slight

elliptic form of shell. However, by a rare coincidence, all the elements for a demonstration were present. First, by the introduction of steam, all the air was driven out of the uncalked joints; then the expansion of iron from the heat of the steam closed up such leaks as workmen had not reached. The shower was properly timed, and of sufficient intensity and duration to condense all the steam and produce a vacuum, after which the shell yielded to still greater distortion, and finally collapsed from end to end, bending and breaking both heads.

A SIMILAR incident is related by a man who was interested in the installation of a steam plant, and who detailed the ever-present small boy on an errand to replenish the oil supply from a shop close at hand. The lad, seizing an empty gallon can, and, holding it for a moment under the boiler gauge cock, blew a charge of dry steam into it, by way of cleansing the receptacle; then, quickly inserting the cork, he started on his mission at a run. The road led directly through a covered bridge, spanning a stream of water. The dampness of the place condensed the vapour confined in the can, and it collapsed with a loud report. The boy returned with a look of terror on his face and holding by the handle a flat plate, the remains of what a few moments before was a bright and symmetrical gallon can. However, the lesson was lost on him, as he could never quite understand what hit his can. In probably neither of the instances referred to could any of those responsible be fairly censured; it would be exacting too much of human foresight, although in matters of greater moment such possibilities might be considered and anticipated by the deliberate and experienced engineer.

OF the first ship, properly speaking, of the British Navy, known as the *Great Harry*, to which reference has previously been made in these pages, the following additional particulars are given in an old number of the *Mechanic's Magazine*, dated October 25, 1823, together with a drawing from which the annexed illustration has been prepared. The *Great Harry* was built by King Henry VII. at a cost of £14,000, and was burnt at Woolwich, through accident, in 1553. Though King Henry, as well as other princes, hired many ships, exclusive of those which the different seaports were obliged to furnish, he seems thus to have been the first king who thought of avoiding this inconvenience by raising such a force as might be at all times sufficient for the services of the State. Historians tell that he caused his navy, which had been neglected in the preceding reign, to be put in a condition to protect the British coasts against all foreign invasions, and that in the midst of profound peace he always kept up a fleet ready to act. Although British naval power was thus considerable during his reign, there was no occasion for its exercise till the reign of his son, Henry VIII. By his prerogative, and at his own expense, he laid the foundation and settled the constitution of the present royal navy. An Admiralty and Navy Office were constituted and commissioners were appointed by him; regular salaries were settled not only for the admirals and



THE FIRST BRITISH MAN-OF-WAR, BUILT IN 1515

vice-admirals, but for his captains also and seamen, and the sea service at that time became a distinct and regular profession. Henry it was, too, who founded the Deptford, Woolwich, and Portsmouth Dockyards and the Trinity-House.

Having entered into a league against France, Henry fitted out a fleet, under the command of Sir Edward Howard, Lord High Admiral. In the engagement which took place between the French and British fleets in August, 1512, the *Regent*, a ship of 1000 tons, which was at that time the largest vessel in the British Navy, was burnt, and, to replace it, the *Great Harry*, or, as it was also known, the *Henry Grace de Dieu*, was built in 1515. The original drawing of the ship, which is faithfully reproduced in the illustration on the preceding page, is said to have been an exact representation of the vessel, with the exception of the masts and rigging. The vessel appeared to be of about 1000 tons burden, and was manned by 349 soldiers, 301 mariners, and 50 gunners. She had four masts and port-holes on both decks and in other parts. Before the time of her construction the cannon were placed above deck and on the prow or poop. One Decharges, a French builder, at Brest, is said to have invented port-holes. In a list of the British Navy, as it stood on January 5, 1548, the *Great Harry* is said to have carried 19 brass and 103 iron pieces of ordnance. The name of the ship is supposed to have been changed in the reign of Edward VI. to *The Edward*, which, on August 26, 1552, was reported to be still "in good case to serve," and was ordered "to be grounded and calked once a year to keep it tight." No subsequent notice of the ship has been met with in the British naval annals.

The already practically foreshadowed widening use of aluminium conductors for electric transmission purposes adds interest to Lord Kelvin's recently expressed opinion of them. The weight of aluminium required, he said, is almost exactly one-half of the copper which would produce the same effect. The diameter of cable is 28 per cent. in excess of one made of copper, and the cost of insulation for an underground cable is increased in about the same proportion when we pass from copper to aluminium. Aluminium is not a pleasant metal to deal with, but its high conductivity will make it invaluable for overhead transmission. It is true also that the weight to be supported on posts is half of copper, but the surface exposed to the wind is greater, and its strength is not great. The chief drawback to its use, especially overhead, is its liability to become rotten. This defect does not exist if the metal be pure, and especially if free from sodium. But exposure to the atmosphere, especially near the sea, induces deterioration. The fact that aluminium is easily oxidised ought not to condemn it. The same is true of iron and steel, and yet we do not hesitate to place structures of these metals in exposed positions. Only we paint them; so Lord Kelvin proposes that we paint or varnish aluminium conductors wherever necessary. A few hundred yards of 1¼-inch aluminium wire were put up by Lord Kelvin on a Scotch estate somewhat over a year ago, and on this line he is watching the effects of weather.

Since aerial navigation began to seriously occupy the minds of the public, newspaper artists have frequently amused themselves by drawing imaginary pictures of the future, showing the air full of queer-shaped vehicles, with balloons, propellers, and fans. But it is thought likely that unless some legislation is passed on the subject, entanglement of the sunshine in kite-strings and obscurement of the heaven by kite-paper may become a vexatious reality before the artists have time to paint it. The elevation of advertising banners through the medium of kite tandems was a natural development of the fury for outdoor display which has in the last five years more than doubled the amount of money expended in advertising. In the first place, it was the custom to paint various crude legends upon rocks along the railways. Then farmers were persuaded to let the sides and roofs of their barns for the sake of having them painted. Then wooden signs were erected in the fields, and the principle of making railways

hideous has been applied with a vengeance everywhere. Now, however, come kite-flying companies and offer to place banners in the heavens for comparatively moderate charges. In the city of New York the idea has been taken up by several business houses, and a number of firms have contracted for aerial advertising. The kites suspending the banners are flown from the tops of tall buildings, and a number of these have been regularly leased for that purpose.

It is several years since what was probably the first electric gun made its appearance, designed on the principle of having the projectile propelled, or rather pulled, through the gun tube by magnetic attraction. Practically, the thing was a hopeless failure, as an enormous electrical horse-power would have been required to accomplish anything like the effects produced in guns using explosives; but since its time the electric-gun idea has taken other and more promising shapes, involving the use of centrifugal force, with the electric feature a comparatively unobtrusive one. Of one of these guns, ascribed to the inventiveness of James Judge, of Newcastle-on Tyne, England, it was told in several recent accounts that an electric motor, attached to the side of the gun proper, caused a disk to revolve at a very high rate of speed. The bullets, which were introduced into the interior of the disk at the axle, travelled along curves in the interior to the circumference, and were there impelled through a barrel. It was claimed that this disk would rotate, under the influence of the motor, at the rate of 12,000 revolutions per minute, and would eject shots from the muzzle of the gun with an initial velocity of 2000 feet per second. One of the chief characteristics of the gun was said to be that it would maintain a continuous fire. If necessary, a shot could be discharged at every half revolution. The bullets were to be spherical, measuring three-sixteenths of an inch in diameter. Test results, too, were published, crediting the gun with remarkable performances,—power to penetrate a 7-16-inch iron plate at 400 yards, even though only a relatively low disk speed was maintained,—something like 2500 revolutions per minute,—entire absence of heating of the gun barrel due to the continuous stream of cold air said to be impelled through it by the turning of the disk, and others.

Almost simultaneously with the particulars of this gun, however, has come the information that about four years ago General Eugene Griffin, vice president of the General Electric Company, of New York, patented a practically identical invention in Germany. In his patent, it appears, General Griffin pointed out that the gun could be made not only a portable field piece, but that if employed in a permanent fort or on a ship, several could be fed from one central generating plant. As General Griffin pointed out, also, the advantage of such a gun is that it operates without noise, smoke, or the appearance of fire, and it is not annoying because of fumes, etc., to the men in charge. It has few, if any, elements of danger, and can be easily concealed from the enemy. Furthermore, from revolving several barrels, it should be much more durable and longer useful than the ordinary gun, the barrels of which, as is well known, become useless after the discharge of a relatively small number of shots. Such a gun should be found very serviceable in operating fireworks, the throwing of fire-balls, in the life-saving service, and in the signal service. It now remains to make some practical use of this device, which appears to have promising features.

In reply to an inquiry as to what would happen in the event of a train filled with passengers being stopped for half an hour in the middle of a tunnel on the Central London Railway, or other of similar construction, Sir Benjamin Baker, the chief engi-

neer of that railway, recently stated in the London *Times* that the purity of the air breathed by the passengers would be practically unaffected, but that the temperature might appear somewhat high in contrast to the cold tunnel unless the end doors and side ventilators were all kept open. Numerous experiments have proved that the oppressive condition of air sometimes complained of in railway carriages above or below ground is related to the temperature and not to the purity of the air; so that, whilst in summer people may complain of being suffocated, though all the carriage windows are open, in winter they feel no such oppression though they remain all night in a well-filled carriage with every window and ventilator studiously closed. It has been practically demonstrated that a live man might be sealed up in a lead coffin for half an hour without any resultant feeling of oppression, provided he were treated as frozen mutton in a cold store, so that the air he breathed, though astoundingly foul from repeated breathing, might still remain cold. The worst that could happen from a stoppage of many hours in a small tunnel would be that some of the passengers might get as warm as if they were in the cheap seats of a theatre, assuming they remained in the carriages, which is not at all likely, as convenient gangways are provided along which passengers could walk to the nearest station, and supplementary lights are available in the event of a breakdown of the ordinary system.

CHARLES HILL MORGAN

A BIOGRAPHICAL SKETCH

WITH the year just ending Mr. Charles Hill Morgan retires from the presidential chair of the American Society of Mechanical Engineers. Mr. Morgan was born in 1831, of New England parentage, and as his father was a mechanic of limited means, Charles was obliged to commence work in a factory at the age of twelve, his early education being such as was afforded by the Massachusetts district school of sixty years ago, and the Lancaster Academy. When fifteen he entered the machine shop of his uncle, J. B. Parker, of Clinton, Mass., as an apprentice. At seventeen he determined to learn mechanical drawing, and through his efforts a class for the study of this subject was formed, taught by the late John C. Hoadley, then civil engineer of the Clinton Mills. Those few lessons in drawing, taken at night, after twelve hours of work in the shop, were the most important factor in establishing Mr. Morgan's mechanical career, and perhaps of several in that class. In 1852, when twenty-one years old, Mr. Morgan was put in charge of the Clinton Mills dye-house. He devoted himself to the study of chemistry with great zeal, and filled his new position with entire success, gaining valuable experience in the management of subordinates. For a time he was draughtsman for the Lawrence Machine Company. Later, from 1855 to 1860, he was mechanical draughtsman for the distinguished inventor and manufacturer, Erastus B. Bigelow. In association with him and Charles H. Waters, the agent of the Clinton Wire-Cloth Mills, he gained an invaluable experience, and may be said to have been trained in a hive of invention.

In 1860 Mr. Morgan joined his brother, Francis Henry Morgan, in Philadelphia, and was for two years engaged in the manufacture of paper bags. In 1864 Hon. Ichabod Washburn was in need of a superintendent for his

works, for the manufacture of wire, at Worcester, Mass. His friends at Clinton, engaged in the manufacture of machinery and wire-cloth, warmly recommended Mr. Morgan, and Mr. Washburn accordingly engaged him as superintendent of manufacturing for the firm of Washburn & Moen. Four years later, when a joint-stock company was organised and incorporated under the name of Washburn & Moen Manufacturing Company, Mr. Morgan was appointed general superintendent, and made a number of trips to Europe for the purpose of visiting the mills of England, Belgium, Germany, France, and Sweden. From these visits, from publications devoted to wire manufacturing, and from patents issued both in Europe and America, he gathered a valuable fund of information, the fruits of which were seen in the increased excellence, variety, and amount of the company's manufactures. For eleven years Mr. Morgan was one of the directors of the company.

An advance step in the wire business with which he has been prominently identified was the development of the continuous rolling-mill, designed and originally constructed in Manchester, England, by Mr. George Bedson. This continuous rolling was an important improvement on the ordinary rolling previously practiced. After starting the Bedson mill in Worcester, in 1869, it became evident that its production was limited by the imperfections of the ordinary hand reel. Mr. Morgan's first important improvement was, therefore, a power reel; next came the practical development of a continuous train of rolls, having horizontal rolls only. The first rolling-mill had, alternately, horizontal and vertical axes. Experience has shown that this mill, consisting of a series of horizontal rolls with intermediate twist guides between the rolls, giving the metal one-quarter of a turn in its passage from one pair of rolls to the next, was far superior to a mill with alternate horizontal and vertical rolls.

Nine years after the construction of the Bedson mill another mill, from new designs furnished by Mr. Morgan, was built on the Belgian and continuous plans. This mill, the result of Mr. Morgan's studies, was known as the Combination Mill. The third improvement was Mr. Morgan's invention of automatic reels, such as are now in common use in every rod mill in this country. These reels were completed and a successful test was made on March 10, 1886.

Since severing his connection with the Washburn & Moen Manufacturing Company, in 1887, Mr. Morgan has devoted his attention to the Morgan Spring Company, manufacturers of wire and springs, founded in 1881, and the Morgan Construction Company, of Worcester, Mass., manufacturers of rolling-mill and wire-drawing machinery. His work and that of his associates in the last named company has been most successful, and their designs and machinery are being widely adopted. The continuous rolling of such material as billets, merchant bar, rods and hoops, together with the disposition of the product after it has been rolled, has been given special attention, and a large number of important installations have been made. The continuous method of heating billets, while not strictly new in itself, has been carefully developed and introduced, culminating with the continuous gravity discharge furnace invented by Mr. Morgan.

While he thus took a leading part in developing the wire industry of America, he rendered services of far-reaching importance as well in an educational way, in his capacity as trustee of the Worcester Polytechnic Institute. Indeed, of the two services the latter was, perhaps, the most indispensable. Economic interests would have called for some man to develop the wire industry, but rarely would another be found under whose guidance the Washburn machine shop would have been successful.

In March, 1886, the Hon. Ichabod Washburn made his gift to establish the machine shop and working mechanical department of the Worcester Institute. That shop was to be unique in its plan. It was, to all intents and purposes, to be a business establishment and not a

school. The coming of the students into the shop for instruction was to be an important feature, but a feature added to an establishment complete in itself, without the students. One of the trustees of the Institute, who has served as a trustee from its founding, has said:—

"I regard the service of Mr. Charles H. Morgan as one of the most important benefactions ever conferred upon the people of Worcester. When Deacon Washburn endowed the machine shop connected with the Worcester County Free Institute of Industrial Science, now known as the Polytechnic Institute, everybody who took an interest in that school felt the gravest anxiety as to the result. Deacon Washburn was getting to be an old man, and his health was feeble. So far as the trustees were informed, there had been no instance in this country, and very few in the world, where an institution of education had conducted profitably a manufacturing establishment, unless the work were of the simplest and cheapest character. To undertake the management of a machine shop requiring a high degree of skill, and to make costly and complicated machinery, such as engine-lathes, was a most hazardous experiment.

"Deacon Washburn recommended to the trustees to elect Mr. Morgan as one of their associates, with the expectation that he would give the shop the benefit of his great mechanical genius and large experience. Deacon Washburn died before the establishment was fully under way. Mr. Morgan's sagacity, his constant oversight, his inventive genius, and his great business capacity have been constantly at the service of the school. The machine shop has been entirely successful, and is now recognised everywhere as a most important and valuable part of the institution. I will not say that no other person could have been found under whose guidance that shop would have been successful, thereby contributing the largest part of the success of the school itself; but I have never known or heard of a person who would have done it, and certainly what has been done there is largely his work."

Mr. Morgan's election as trustee took place early in 1866 The walls of the Washburn machine shop were about half finished when Mr. Washburn was stricken down with his last illness. To Mr. Morgan he gave the charge of finishing the shop and equipping it with machinery, ready for use. He also commissioned him to select a superintendent of the shop. Mr. Morgan chose Milton P. Higgins, a graduate of the Chandler Scientific School, at Hanover, N. H. Mr. Washburn sent Mr. Higgins' name to the trustees, who elected him superintendent. From the outset Mr. Morgan and Superintendent Higgins have insisted upon having every equipment of the very best quality and the best tools only used for work of the highest standard. Much of what has been accomplished in this real business shop for the practice and instruction of mechanical engineers is the outcome of Mr. Morgan's co-operation, supervision and support. No fame is more sure than that of a benefactor of a well-rounded institution of learning, certain to live and repeat its beneficent influence age after age, and Mr. Morgan's title to the grateful remembrance of the students trained in the Washburn machine shop will strengthen as the years go by.

Mr. Morgan is a member of the British Iron and Steel Institute, of the American Institute of Mining Engineers, and of the American Society of Mechanical Engineers, of which last, as previously stated, he has been president during the year just ended.

S. T. Wellman.

THE NEW PRESIDENT OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

SEE PAGE 238

CASSIER'S MAGAZINE

VOL. XIX JANUARY, 1901 No. 3

MODERN OCEAN COAL GLUTTONS

THE PRICE OF HIGH OCEAN SPEEDS

By George Ethelbert Walsh

THE struggle for supremacy on the ocean between the transatlantic steamship companies has, for more than half a century, stimulated naval constructors to increasing effort in designing and building steamers of great carrying capacity and speed. The reduction in the time required to cross the ocean from continent to continent has been a matter of world-wide import, and the appearance of each new contestant in the race against time has been eagerly awaited, and her performances watched carefully and anxiously. The limit of speed has time and again been declared to have been reached, and further efforts in this direction predicted to result in failure. In the evolution of the steamship there have been changes in structure and machinery that builders of one decade have condemned as unsatisfactory, while those of another have demonstrated their fitness and serviceableness. Even in the matter of length of hull, the opinion of one generation is revised by that of another. The reaction which followed the failure of the *Great Eastern* convinced constructors that the smaller steamers were the more profitable and serviceable, and the day of the big steamer was declared to have passed, and the limit of size reached.

The present tendency in shipbuilding, however, is sharply the reverse of that decision of half a century ago; the big steamer is not only often the most profitable, but also the most serviceable. This

COALING AN ATLANTIC LINER

BY PERMISSION OF S. W. STANTON

THE TRANSATLANTIC STEAMSHIP "BRITANNIA," OF THE CUNARD LINE, 1840. ARRIVED AT BOSTON JUNE 2, 1840, ON HER FIRST VOYAGE ACROSS THE ATLANTIC. WOODEN HULL. 207 FEET LONG. 34.2 FEET BEAM. ENGINE WAS OF SIDE-LEVER PADDLE TYPE, HAVING A SINGLE CYLINDER, 72½ INCHES IN DIAMETER BY 82 INCHES STROKE. DAILY COAL CONSUMPTION ABOUT 38 TONS.

tendency to increase the size is noticeable both in the freight and passenger service. The new Pacific ocean liners will be of enormous carrying capacity, comparatively slow of speed, and built on lines that will peculiarly adapt them to the waters of the Far East. In the Atlantic ocean steamers the climax in size has been reached in the great *Oceanic*, of the White Star Line, with a total length of 704 feet, and a beam of over 68 feet. In the past year or two it has been freely predicted by naval constructors and shipbuilders that the steamers of the near future will be a thousand feet in length, and at the present rate of growth this time is rapidly approaching. To eclipse the *Oceanic* in size, the Hamburg-American Line has ordered a vessel, to be launched in the year 1903, with a total length of 750 feet, and a beam of 76 feet. According to the plans, she will be able to carry 2000 passengers and 12,000 tons of cargo, and will thus be by all odds the biggest carrying vessel in the world. Meanwhile, the North German Lloyd Line is building a mammoth steamer at the Vulcan Works, at Stettin, in Germany, whose dimensions are unofficially reported to be 752 feet, with correspondingly great beam. As these two steamers will be launched in the same year, the struggle between them for ocean supremacy may prove as interesting as that between the *Deutschland* and the *Kaiser Wilhelm der Grosse*.

The development of the Atlantic steamer is thus along the lines of both size and speed. While some are confident that the speed limit is nearly, if not quite, reached in the records of the *Deutschland*, no one predicts that the length and beam of ocean steamers have reached the danger point. Since the building of the *Great Eastern* marine architecture and science have advanced wonderfully, and the strength of a steamer's hull has been increased fully as much as the propelling power, so that the old theory of a few decades ago that the long steamer was in danger of breaking in two in a heavy seaway is no longer entertained. The structure of the modern steamer's hull is sufficiently strong to withstand any shock that the sea waves may give to it, and the size of steamers will be limited only by the question of profit, which must ever bear a direct ratio to the cost of building, operating, and management.

The speed of the ocean liner must be regulated by the same laws. There are indications that the speed limit has nearly been reached. The fast steamers are claimed to be unprofitable investments without government subsidies, and mails and passengers alone are not sufficient to pay for the heavy cost of operation. As an advertising medium, however, each transatlantic line feels called upon to have at least one record-breaker in service, though the real profit of the company comes from the slow steamers with enormous carrying capacity and low consumption of coal. During the short summer season, when travel across the Atlantic is great, the fast steamers may earn good interest on the investment, but during the rest of the year they lose money for their owners.

It is not strange, therefore, that the transatlantic companies are not directing all their attention to the building of record-breaking steamers. The new large ship of the Hamburg-American Line will not be designed for high speed, but rather for great carrying capacity and moderate speed. According to the plans, she will not have a sustained record of more than eighteen knots an hour, while she will be able to carry 300 more passengers than the steamer *Deutschland*, of the same line, and twice as much cargo. The latter may win speed laurels for the company, but the projected new vessel will make the money that the latter may lose in the long run.

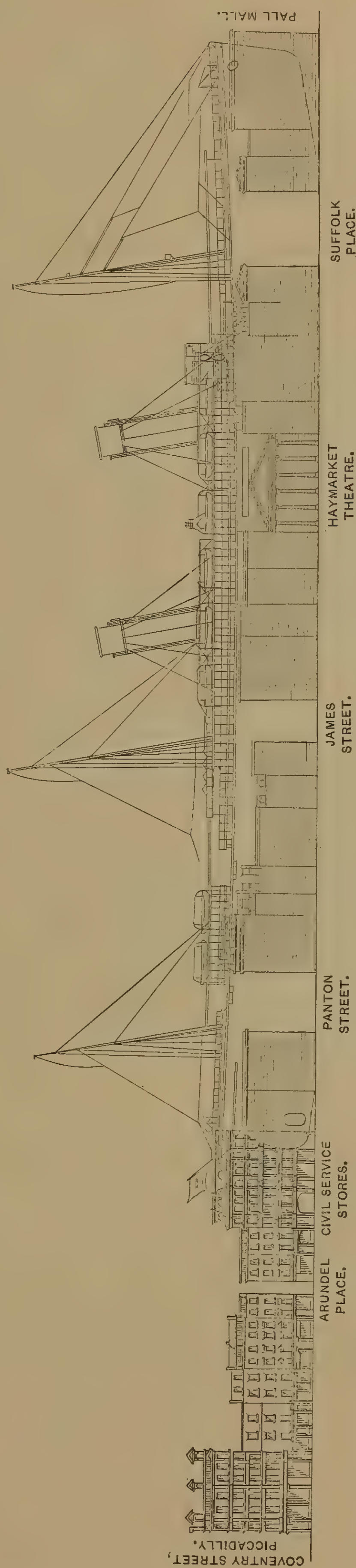
Many of the record-breaking steamships of the past have gradually been turned into comparatively slow cargo and passenger carriers. It is not that their speed has been so far superseded by more recent steamers, but that they have proved more profitable when run at lower speed, carrying cargoes of general merchandise. Many an old-time ocean greyhound is doing service to-day

THE WHITE STAR LINER "OCEANIC" ALONGSIDE THE LANDING STAGE AT LIVERPOOL. LENGTH, 704 FEET. BREADTH, 68 FEET.
DISPLACEMENT, 28,000 TONS. HIGHEST AVERAGE TRIP SPEED, 20.48 KNOTS

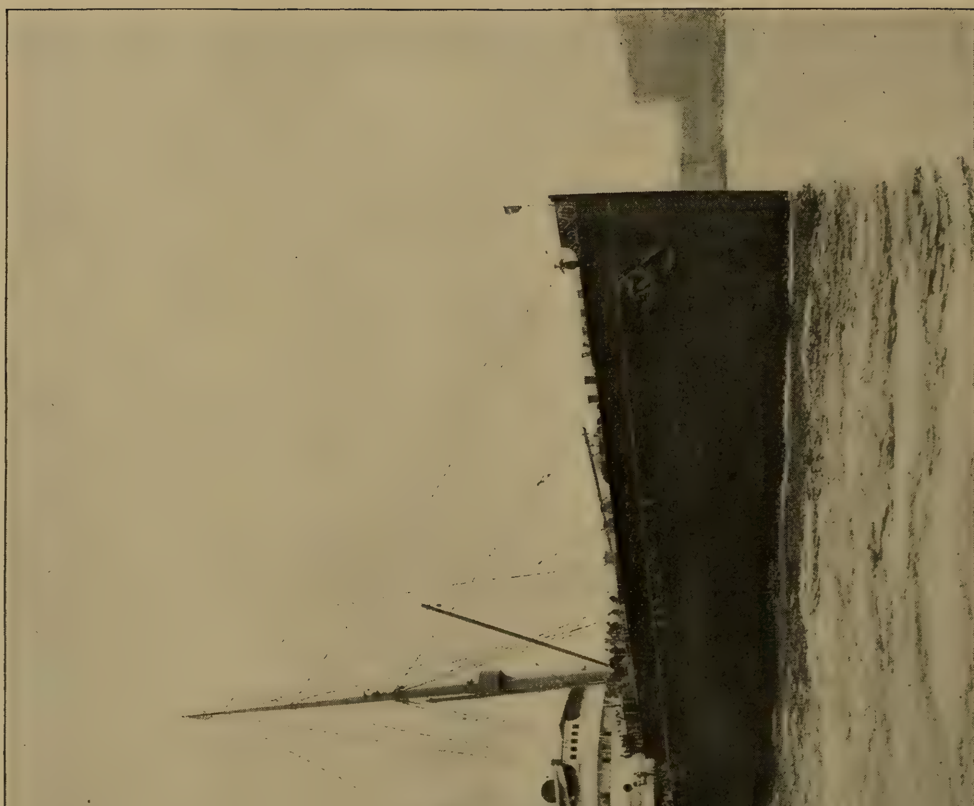
as cargo carrier, making money for its owners, while the newer steamers may be winning glory for speed, but losing money for their owners, unless properly subsidised by their respective governments. The reason for this is not far to seek, though it is one that is little spoken of outside of the inner circles of the companies operating the big liners. In the records of speed the matter of coal consumption is carefully avoided, and the fuel cost of operating the fast liners can be only conjecturally expressed in terms.

To break an Atlantic record costs far more than the public imagines. The initial expense of building the ship represents only a part of the actual cost of wresting the record from some former possessor. The question of building faster steamers must, to a certain extent, be affected by the cost of coal and the possibility of economising in the consumption of fuel to produce a given speed result. So far, the marine architects who have designed and floated the magnificent racers of the deep have made little or no attempt to economise in fuel. Larger and faster ships have simply meant more powerful engines, larger furnaces, and greater coal-consuming capacity. At the present rate of increase in coal consumption the future liners of eight or nine hundred feet, with speed corresponding to the increased dimensions, must prove veritable gluttons in their use of fuel, and the cost of operating them will place them among the most expensive luxuries of the age. The matter even of simply getting the coal on board a swift ocean steamer in time to enable it to sail at its appointed day and hour has already become a serious problem, and it has been found necessary for the lighters containing the supply to warp up alongside the steamer almost before the latter has been secured at its pier.

When the *Deutschland* or the *Oceanic*, —the first the fastest, and the second the largest steamer in the world,— comes into port, the problem of coaling her in time for her next scheduled sailing of only a few days off is one that requires considerable tact and energy to



THIS DIAGRAM, SHOWING THE "OCEANIC" IN A WELL-KNOWN LONDON THOROUGHFARE, THE HAYMARKET, IS MADE TO SCALE, AND AFFORDS A STRIKING ILLUSTRATION, OF THE SHIP'S SIZE



THE HAMBURG-AMERICAN LINER "DEUTSCHLAND" LEAVING PORT. LENGTH, 686 FEET. BREADTH, 67 FEET. DISPLACEMENT, 23,000 TONS. HIGHEST AVERAGE TRIP SPEED, 23.36 KNOTS

solve successfully. Either vessel carries from four to five thousand tons of coal for the trip, and this amount must be turned into her bunkers within three days. The coal is all ordered and conveniently at hand before the ship is reported off, say, Sandy Hook. By the time the big steamer swings into her berth, and while enthusiastic friends are busy welcoming returned travelers, the lighters, laden down with coal, are warped alongside, and almost before the last passenger is off the deck of the steamer, four steady streams of coal are pouring into her sides. Each lighter contains from 400 to 800 tons, and as fast as one has unloaded another is ready to take its place. This continuous coaling usually goes on until almost the last hour of sailing. Hand and machinery alike are employed in the work,—bucket, hand shovel, steam winch, and cars all help to get aboard the one thing necessary to make speed a certainty. It is not the loading and unloading of cargo, either human or freight, that first concerns the company's officers when reaching port, but the apparently simple question of getting aboard enough coal to feed the insatiable boiler furnaces.

The methods of coaling the big steamers have not been brought to a satisfactory conclusion yet, and as now practised it is doubtful whether, with the short periods in port, the coaling could be performed in time on steamers much larger than the *Oceanic*, with speed and coal-consuming capacity proportionately larger. Large iron buckets are filled by hand shovels on the coal lighters, and these buckets are hoisted by the steam winch to the mouth of the coal port, and there the contents are dumped. This is a slow and toilsome method where such enormous quantities have to be transferred in a short time, and some more adequate system must be developed for the future if the record across the ocean is to be brought much below the five-day limit.

THE GRILL ROOM ON THE "DEUTSCHLAND"

When the coal once slides down towards the bunkers it is distributed to

THE FIRST CABIN DINING-ROOM ON THE "DEUTSCHLAND"

different parts of the ship by a small army of grimy workers who labour in the black pit by the glare of electric lights. Over a thousand or two feet of track run around the ship, accommodating hand cars for the distribution of the coal. The fire-rooms and storage bunkers are not always adjoining, and the coal must be carried from one to the other as needed. When the steamer swings out of port and starts on her trip across the ocean, the consumption of the coal begins at a rate scarcely dreamed of by one not familiar with the facts. There is ceaseless activity among the coal-trimmers and heavers until the steamer reaches her destination. On the *Oceanic* there are forty-eight coal-trimmers working in watches of four hours each, and seventy-two firemen who feed it to the furnaces. The work is so hard and fatiguing that the watches are short, and the men are hard-worked at that.

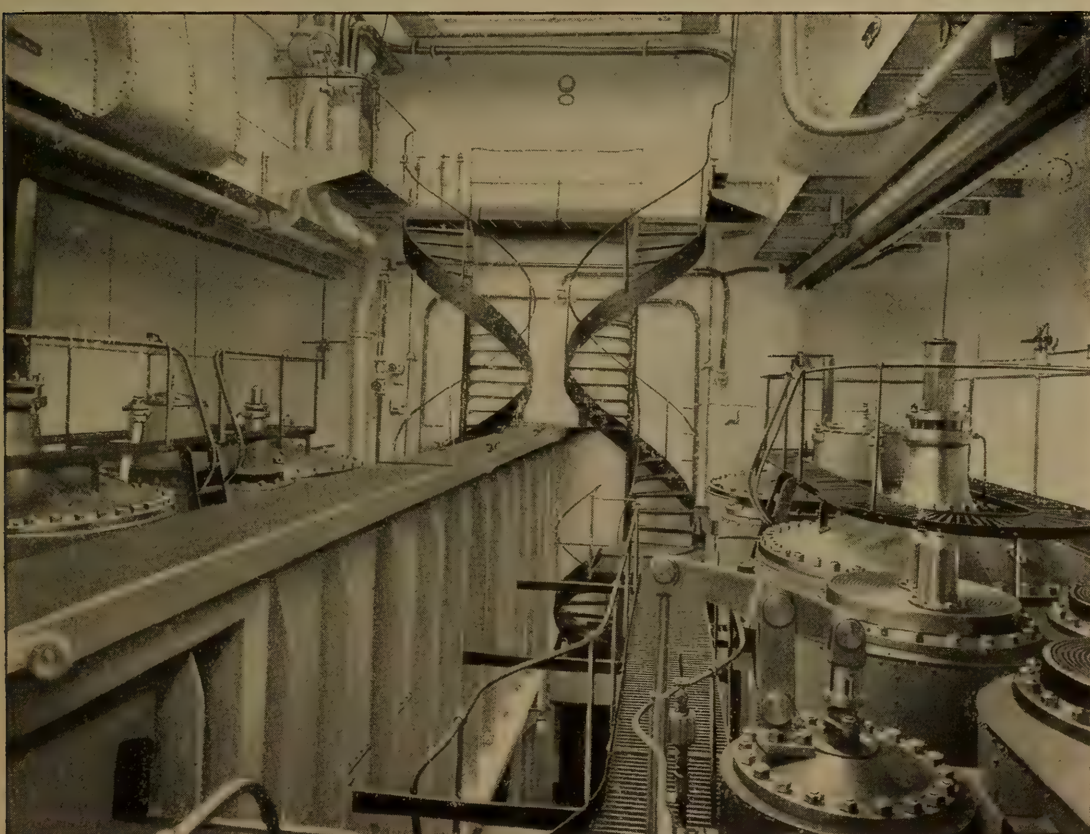
The *Oceanic* develops about 28,000 indicated horse-power, and, while her coal consumption is great, she does not pretend to aspire to record-breaking feats. At a speed varying between 21 and 22 knots she burns about 480 tons every twenty-four hours. But the *Deutschland*, which now holds the world's steamship speed record, is the greatest coal-consumer afloat, with an

average daily consumption of about 570 tons. The *Deutschland* is probably the handsomest, most powerful, and best appointed vessel on the Atlantic, and though 18 feet shorter than the *Oceanic*, she is her superior in speed and efficiency as a racer. But she has demonstrated better than ever the fact that higher transatlantic speed must be purchased at too dear a price under present conditions to make it of much value to the world of commerce.

There is another item of loss to be reckoned with in the operation of the modern ocean racer. The *Deutschland* must be driven at her highest speed continually throughout her trips, and she will make a round trip to Europe in three weeks instead of one in four or five weeks, as in the case of the slower steamers. This imposes a strain upon the ship that must help to shorten her life, and both engines and hull must yield to the hard work much earlier than on ordinary slow steamers. The supreme usefulness of such a racer is, of course, limited by its ability to surpass all other steamers in speed. Then,

SOME TRANSATLANTIC STEAMSHIP DATA

	Length.	Beam.	Displacement.	Indicated Horse-Power.	Highest Average Speed.	Average Daily Coal Consumption,	Highest Daily Run.
	Feet.	Feet.	Tons.		Knots.	Tons.	Knots.
Oceanic	704	68	28,000	28,000	20.48 Per trip	480	524
Deutschland	686	67	23,000	35,000	23.36 Per trip	570	584
Kaiser Wilhelm der Grosse	648	66	20,000	28,000	22.79 Per day	500	580
Lucania	622	65	19,000	30,000	22.01 Per trip	475	562
St. Paul	554	63	11,600	20,000	21.78 Per day	300	540



AN UPPER ENGINE ROOM PLATFORM ON THE "OCEANIC"

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THE NORTH GERMAN LLOYD TWIN-SCREW STEAMSHIP "KAISER WILHELM DER GROSSE." LENGTH, 648 FEET. BREADTH, 66 FEET.
DISPLACEMENT, 20,000 TONS. HIGHEST DAILY AVERAGE SPEED, 22.79 KNOTS

THE TWIN-SCREW CUNARD LINER "CAMPANIA." LENGTH, 622 FEET. BREADTH, 65 FEET. DISPLACEMENT, 19,000 TONS. HIGHEST AVERAGE TRIP SPEED, 21.88 KNOTS

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THE AMERICAN LINE STEAMSHIP "ST. LOUIS," SISTER SHIP OF THE "ST. PAUL." LENGTH, 554 FEET. BREADTH, 63 FEET. DISPLACEMENT, 11,600 TONS.

when she has been replaced by one of greater speed, her trips will be less frequent, and she will not be driven to keep up her maximum speed. The deterioration of a steamer under this strain must be much more rapid than the owners could wish.

One of the slower, but still swift steamers, consumes coal fast enough, but the record is far better for the company than that of the *Deutschland* and *Oceanic.* The three American Line steamers, *New York*, *St. Louis*, and *St. Paul*, carry on an average between 3,300 and 3,700 tons of coal. This amount is made up on either side of the Atlantic for the trip across. The *St. Paul*, as an illustration, has a displacement of slightly over 16,000 tons, against the *Deutschland's* 23,000, and the *Oceanic's* 28,000. She develops 22,000 horse-power, and her coal consumption for her 21 knots is sufficient to alarm the owners, and make them reticent about the question of profit and loss.

In the last ten years the race for the transatlantic record has been far more interesting than at any other period, for it has been in this decade that the great coal burners have been built. It is also the "twin-screw period" of ocean navigation, and with the twin-screws have come greater speed, more and heavier engines, and corresponding increase of boiler power. The American liners *Paris* and *New York* were the first to embody the new and radical departures from the old methods of shipbuilding, and in many respects they marked an entirely new era in shipbuilding. They were, from the first, brilliant successes in speed and seaworthiness, but they were also responsible for a new era of coal consumption that has at last brought the steamship companies to the point where they are anxiously looking for some let-up. The *Paris* soon broke the record from New York to Queenstown, making the trip in much less than six days at an average speed of 20 knots an hour. The *Teutonic* and *Majestic*, which followed, though larger in every

THE LIBRARY ON THE "OCEANIC"

ONE OF THE DECK PROMENADES ON THE "KAISER WILHELM DER GROSSE"

way, were slower in speed, and less expensive in operating. With only 18,000 indicated horse-power, against the 20,000 of the *Paris*, the *Teutonic* consumes only 300 tons of coal per day to develop her 19½ knots.

The two magnificent steamers of the Cunard Company, the *Lucania* and the *Campania*, which soon followed the launching of the American liners, established new ocean records, and new coal-consuming figures. The *Campania*, with 19,000 tons displacement, had 30,000 horse-power, and developed a speed of 22 knots, with a daily coal consumption of about 475 tons. The modern coal gluttons were in full force by this time, and the steamship companies had to confess that the lowering of the record meant not only larger ships, but heavier coal-cost. The *Kaiser Wilhelm der Grosse*, of the North German Lloyd Steamship Company, was built on lines which fully recognised this fact. She is 26 feet longer than the *Campania*, 1 foot greater in beam, and has 1000 tons more displacement. Her fastest trip was made at an average speed of 22.79 knots, covering in one period of twenty-four hours 580 knots. Nevertheless, her horse-power was slightly less than that of the *Campania*, being 28,000, against the latter's 30,000, and her coal consumption a trifle more, amounting, according to the owners' figures, to 500 tons a day.

The *Kaiser Wilhelm der Grosse*, the *Oceanic*, and the *Deutschland* are the three modern steamers that offer the best comparisons and represent the

highest effort of the best marine architects of the day. Differing somewhat in size, shape, and general equipment, they nevertheless present features so much alike that valuable lessons can be drawn from them. The *Oceanic* exceeds either steamer in the matter of length, beam, and displacement, and has the same horse-power as the *Kaiser Wilhelm der Grosse*, but is much slower than this former record-holder. The *Deutschland* develops 35,000 horse-power, against the 28,000 of the other two, and to feed the engines sufficiently to maintain a 23-knot speed she requires the greatest amount of coal ever fed to an ocean steamer. Her high record is thus purchased at an expense of coal that makes her honours seem somewhat doubtful from a financial point of view.

CONTINENTAL STEAM ENGINES

AS SEEN AT THE PARIS EXHIBITION

By W. D. Wansbrough

BEFORE these words appear in print the long lines of gigantic steam-engines at the Paris Exhibition, which were, without doubt, the finest collection of prime movers ever brought together, will have been dismantled, and the Exhibition itself will be but a memory. But even so, descriptions of some of the more prominent examples of Continental engine practice there shown will still be interesting.

One of the most striking exhibits in the Palace of Electricity was that contributed by the German company rejoicing in the remarkably compact title of the Vereinigte Maschinenfabrik Augsburg und Maschinenbaugesellschaft Nürnberg Aktien-Gesellschaft. The Augsburg works of this firm showed, in conjunction with the well known Helios Elektricitäts Aktiengesellschaft, a triple-expansion, four-cylinder, horizontal engine with fly-wheel alternator of unusual size.

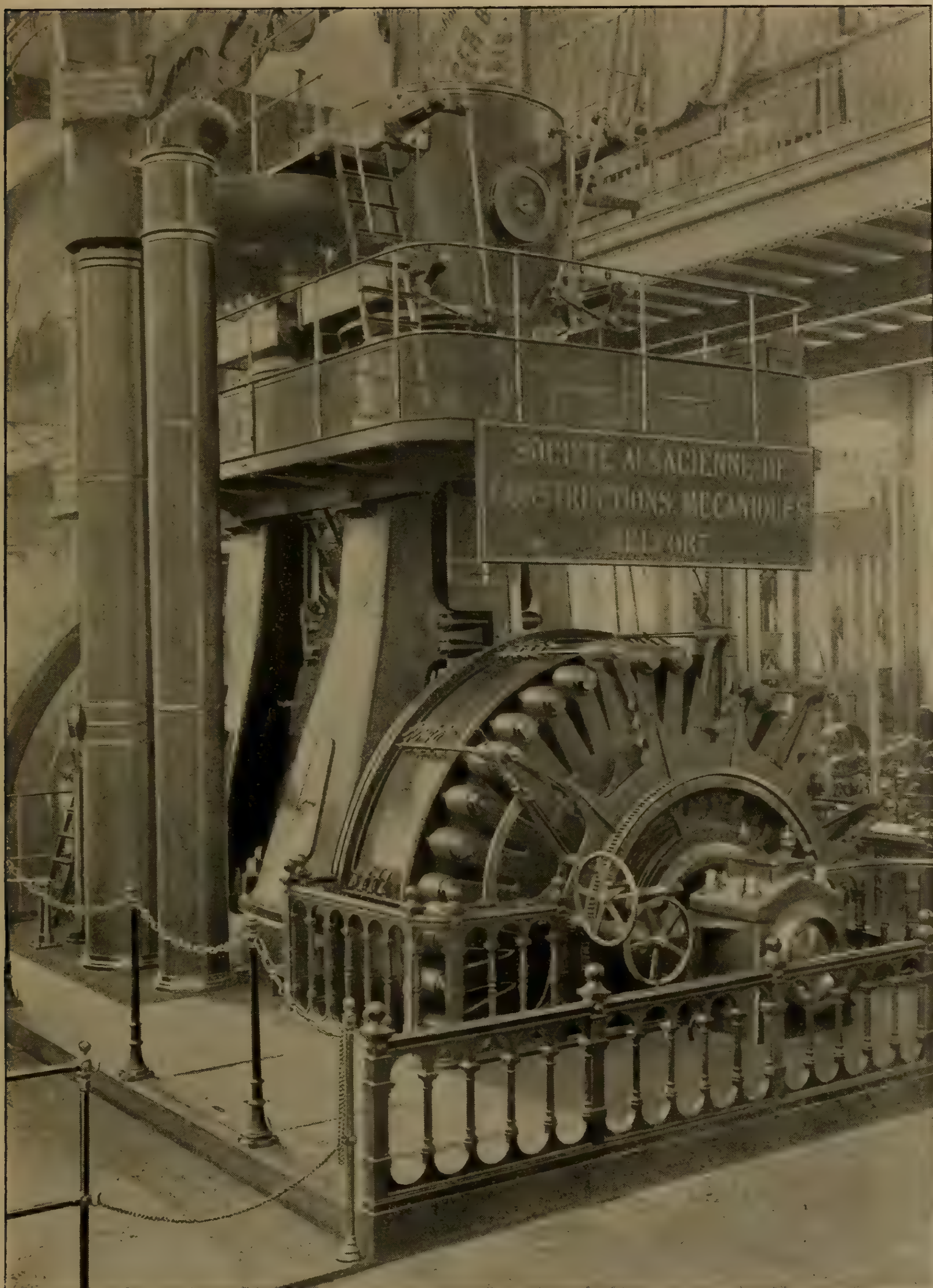
This engine and dynamo were amongst the most powerful of all that were doing active work in the Exhibition, the electrical output at its maximum requiring something like 3000 horse-power to be developed. The extreme height, measured from the bottom of the foundation to the highest point of the alternator, was nearly 44 feet. The diameter of the magnet fly-wheel, made in four parts with twelve double arms, was 26 feet 3 inches across the pole-tips; and its weight, including the poles, was over 76 tons. As will be noticed from the illustration on page 180, the sides of the magnet wheel were plated, as a measure of precaution, thus relieving the cast-iron arms to some extent of the enormous centrifugal and magnetic stresses set up at the speed of seventy-two revolutions per minute.

Each bed-plate, comprising guide trunk and main bearing in a single casting, weighed 15¾ tons; and the crank-shaft, which was of Krupp crucible steel, and hollow, weighed, with its crank-arms and crank-pins, upwards of 17 tons. This was the heaviest single piece in the engine. The cranks were of wrought iron, each with its counterbalance weights forged in one piece weighing 3¾ tons. The connecting rods also were hollow, with the object of reducing the disturbing effect of the reciprocating masses.

The arrangement of the engine was that of a double tandem, there being two low-pressure cylinders placed next to the guide trunks. The high-pressure and intermediate cylinders were placed behind, and connected to the low-pressure cylinders by large and roomy distance-pieces, which were covered in with the same material,—blued steel,—as used for the cylinder lagging. Cylinders and steam jacket casings were each cast in one piece, *i. e.*, the working barrel or liner was not a separate casting forced in, as usual.

The high and low-pressure cylinders were jacketed by their own working steam before it entered the cylinders; the intermediate cylinder and the first receiver were jacketed by direct steam at boiler pressure. In addition to this, all the cylinder covers were jacketed.

The arrangement of dividing the low-pressure cylinder into two was stated to offer the following advantages:—"A more favourable proportion of diameter to stroke; smaller clearances, with consequent greater economy; better division of the respective crank-pressures,

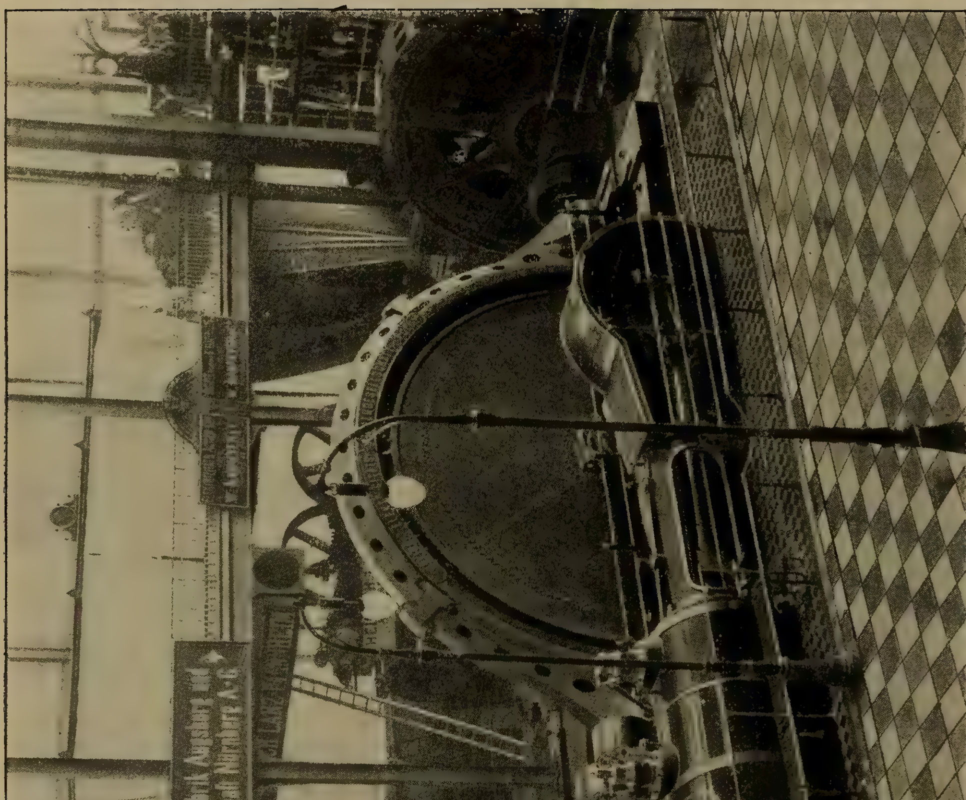


COMPOUND ENGINE BUILT BY THE SOCIÉTÉ ALSACIENNE DE CONSTRUCTIONS MÉCANIQUES, BELFORT

and more even turning effort; and, by having a separate condenser and air-pump for each cylinder, a better vacuum is secured. Again, the pistons and valves, for a given power, are smaller and lighter than with a single low-pressure cylinder; and lastly, the piston-rod guides and crosshead are not heated to such an extent as with a high or intermediate cylinder placed next to the bed."

The diameters of the cylinders were, —high-pressure, 27½ inches; intermediate, 43½ inches; two low-pressure, each 45¼ inches. The stroke was 63 inches, and the revolutions per minute were 72, giving a piston speed of nearly 760 feet per minute. The engine was intended to work with 175 lb. steam, with a cut-off in the high-pressure cylinder of 25 per cent. The normal load was 1600 effective horse-power, with a maximum of 2000 E. H. P.

The valve gear of each cylinder con-



TRIPLE-EXPANSION 2000 H. P. ENGINE BUILT BY THE VEREINIGTE MASCHINENFABRIK AUGSBURG UND MASCHINENBAUGESELLSCHAFT NÜRNBERG, A. G., AUGSBURG AND NÜRNBERG, GERMANY

sisted of four double-beat, equilibrium lifting valves, the high and intermediate admission valves being operated by a cam-motion with tripping arrangement; both, or either, separately, were controllable by the governor. Both the low-pressure cylinders were fitted with the Augsburg system of valve trip-motion; they were coupled together, and adjustable by hand to suit the load. In case the low-pressure cylinders, for any reason, had to work alone, it was possible to connect their gear to the governor. Either of the low-pressure cylinders could also, in case of need, work with the high-pressure cylinder as a tandem engine. All the exhaust valves were worked by a cam-motion on the lay shafts. The condensers were placed below the ground level, and the air-pumps were worked from the crank-pins. In case of a breakdown of either condenser the remaining one could be worked separately. A similar engine at the Linden Cotton Spinning and Weaving Mills, with steam of 160 pounds, superheated, shows a steam consumption of under 11¼ pounds per indicated horse-power per hour. The workmanship and general finish of this engine were of the very highest class, and in the daily work of providing power for exhibition purposes it proved a thoroughly reliable prime mover during the whole period of the Exhibition.

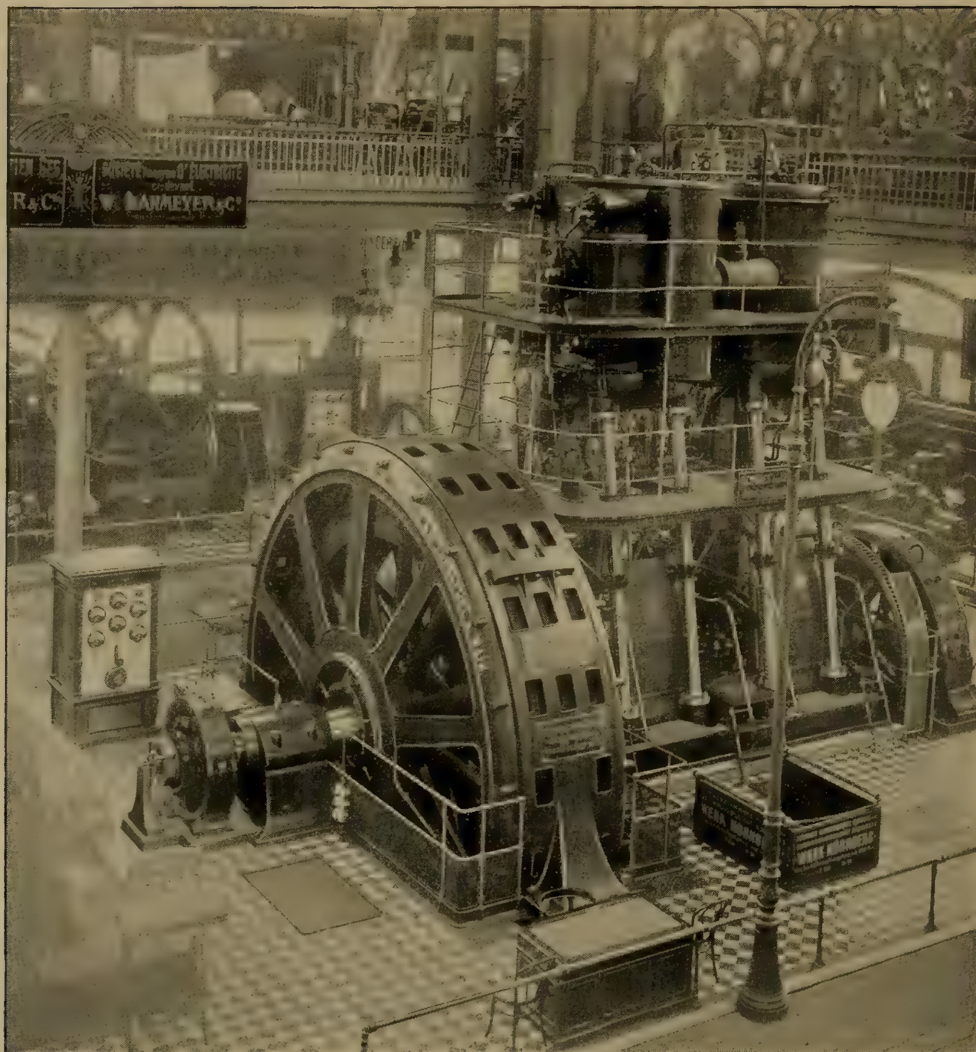
The Nürnberg works of the same firm also showed two vertical engines, —a 2000 H. P. triple-expansion, three-crank engine, and a 1500 H. P. compound, shown on pages 183 and 182. The first-named had cylinders 30½, 49, and 71 inches diameter by 43¼ inches stroke, and ran at eighty four revolutions per minute, with the exhibition steam pressure of 140 pounds per square inch. At its normal speed of 100 revolutions, with 147 pounds pressure and a 25½-inch vacuum, the engine was fully capable of developing 2500 I. H. P. The three cranks were set 120° apart. As will be seen from the illustration, the engine was of the open-front marine type, with cast iron back standards and forged steel legs, the high-pressure cylinder being in the centre. This was fitted with double-beat lifting valves, the admission and exhaust valves for the upper end of the cylinder being placed close together above and below a common steam port; while for the lower end an exactly similar arrangement, but in a different vertical plane, was provided. This system, though reducing the clearance spaces at each end probably to a minimum, makes an enormous addition to the external dimensions of the cylinder casting. The trip gear of the high-pressure admission valves was rather complex, and could not be intelligently described without the aid of diagrams and an explanation which would take up too much room at this moment.

The intermediate and low-pressure cylinders were fitted with Corliss admission and exhaust valves, adjustable, as to cut-off, by hand. The chief feature of this engine was the enormous receiver-pipe running across the whole front of the engine from the intermediate to the low-pressure cylinder, which, to avoid stresses due to expansion and contraction, was fitted with a telescopic packed joint, as shown. The two air-pumps were worked by levers from the intermediate and low-pressure cross-heads, and were exceedingly well-arranged examples of the bucket and plunger type.

An ingenious electrical turning gear was applied to the fly-wheel, so constructed that the moment the engine began to move of itself and the pressure was consequently taken off the barring teeth, the frame containing the motor gear swung out of contact, and, in doing so, cut off the current automatically.

The compound 1500 H. P. engine, shown on page 182, was constructed on precisely similar lines, but the photograph was taken from a much more advantageous point of view. The lubrication in both engines was upon a gravity system, the oil being pumped up into a large overhead tank, from which numerous pipes conducted the oil to every part of the engine.

The general finish of these engines was hardly up to that of the same firm's Augsburg-made horizontal engine just



COMPOUND 1500 H. P. ENGINE BUILT BY THE VEREINIGTE MASCHINENFABRIK AUGSBURG UND MASCHINENBAUGESELLSCHAFT NÜRNBERG A. G.

described. At the same time, these great verticals were massive and well-proportioned engines, and should prove reliable and economical motors for electrical work, for which, of course, they were especially designed.

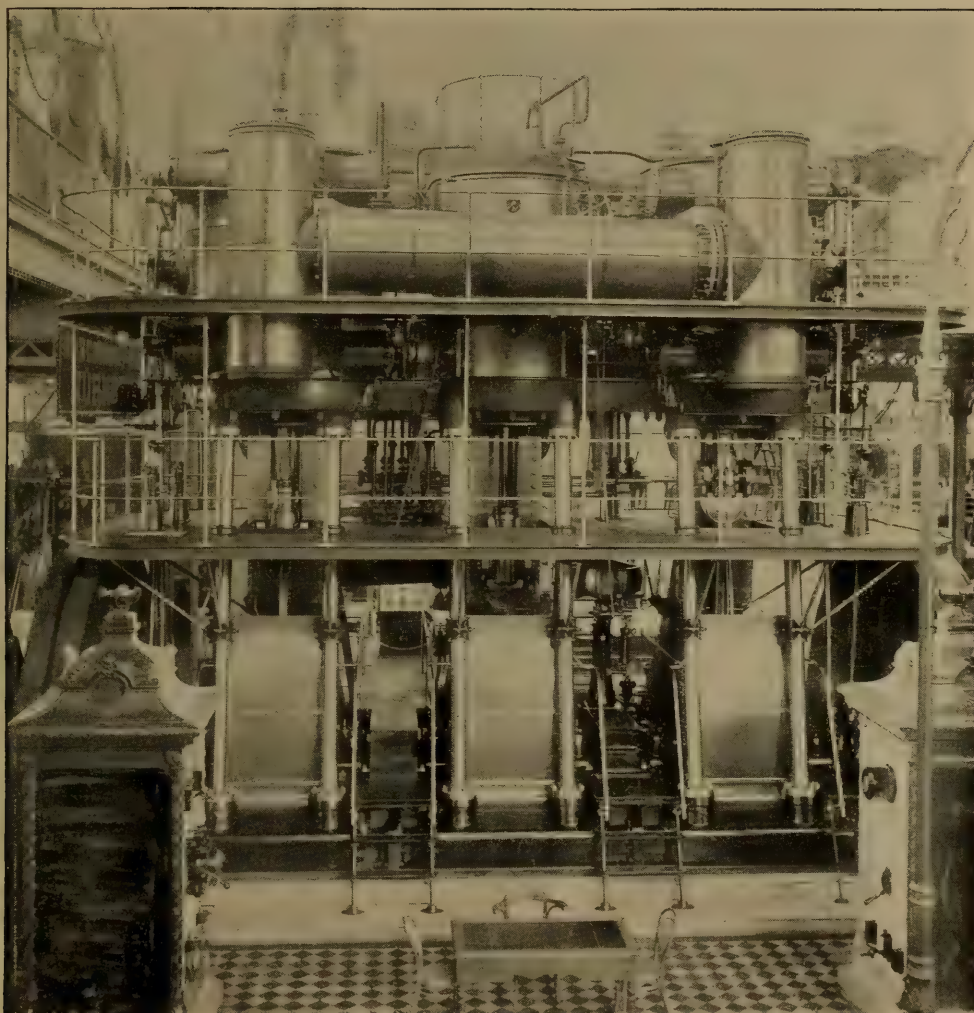
The triple expansion, four-cylinder vertical engine, exhibited by the firm of A. Borsig, of Tegel, near Berlin, was, perhaps, the most conspicuous object in the whole show of machinery, its highest point, the dashpot of the intermediate cylinder, standing 41 feet above ground level. So vast a machine deserves something more than a passing notice, and, aided by the very full particulars placed at the writer's disposal by the makers, he is enabled to describe it in some detail. Illustrations of the engine are given on pages 184 and 185. The high-pressure cylinder is 30 inches in diameter, the intermediate is 46½ inches, and the two low-pressure cylinders are each 52¾ inches, the stroke being 47¼ inches. At its normal speed of ninety revolutions per minute, with an initial steam pressure of 206 pounds per square inch and a twenty-fold expansion, when condensing, this engine is good for 25,000 effective horse-power. At the Exhibition, however, driving a three-phase Siemens & Halske alternator, it ran at eighty-three and one-half revolutions per minute only with 140 pounds steam pressure. The cranks are placed 180° apart, one end of the shaft having a half-coupling forged upon it to which the alternator shaft was coupled, the other end being fitted with a crank-disc

which drove the two single-acting air-pumps placed vertically below the floor level.

The bedplate of the engine was in two parts securely bolted together, each half carrying two main bearings. Between these the bed was trough-shaped, forming oil wells, from which the oil drainage was raised by a couple of small pumps, passed through a filter, and re-

inside and out, by bolts, stood the two massive standards of cast iron with their crosshead-slides. In the front were two forged steel columns, fitting above and below in sockets formed to receive them, giving great solidity to the structure of the engine.

The two low-pressure cylinders, which were firmly attached to each other, were secured to the flanges at

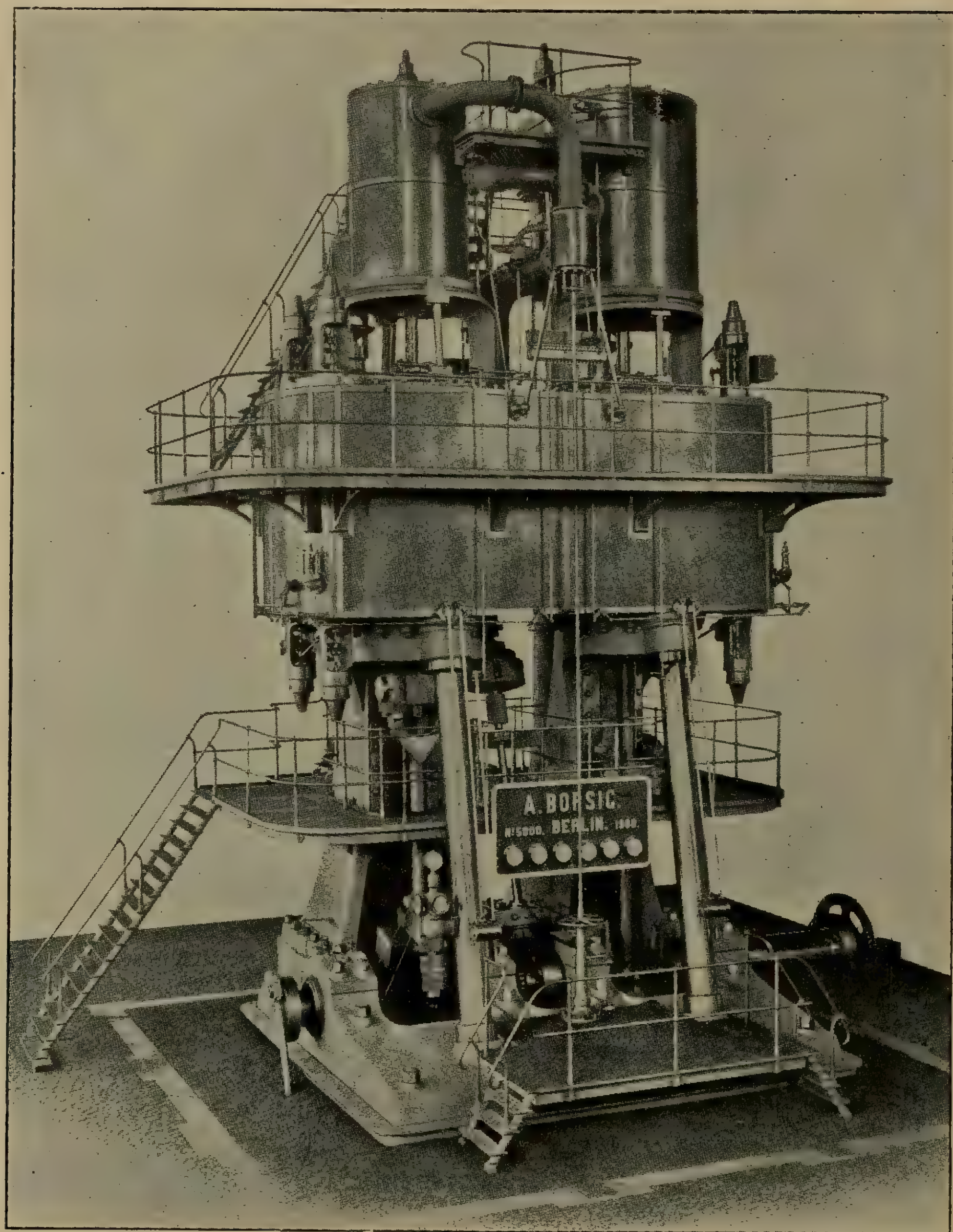


TRIPLE EXPANSION, THREE-CRANK, 2000 H. P. ENGINE BUILT BY THE VEREINIGTE MASCHINENFABRIK AUGSBURG UND MASCHINENBAUGESELLSCHAFT NÜRNBERG A. G.

distributed to the bearings. The fly-wheel was 21 feet 6 inches in diameter, weighing nearly thirty-nine tons, and was keyed on the shaft which was swelled to receive it just inside the half-coupling. It was provided with internal teeth into which the pinion of an electric barring apparatus geared when required for starting or turning the engine. Upon the bedplate, secured,

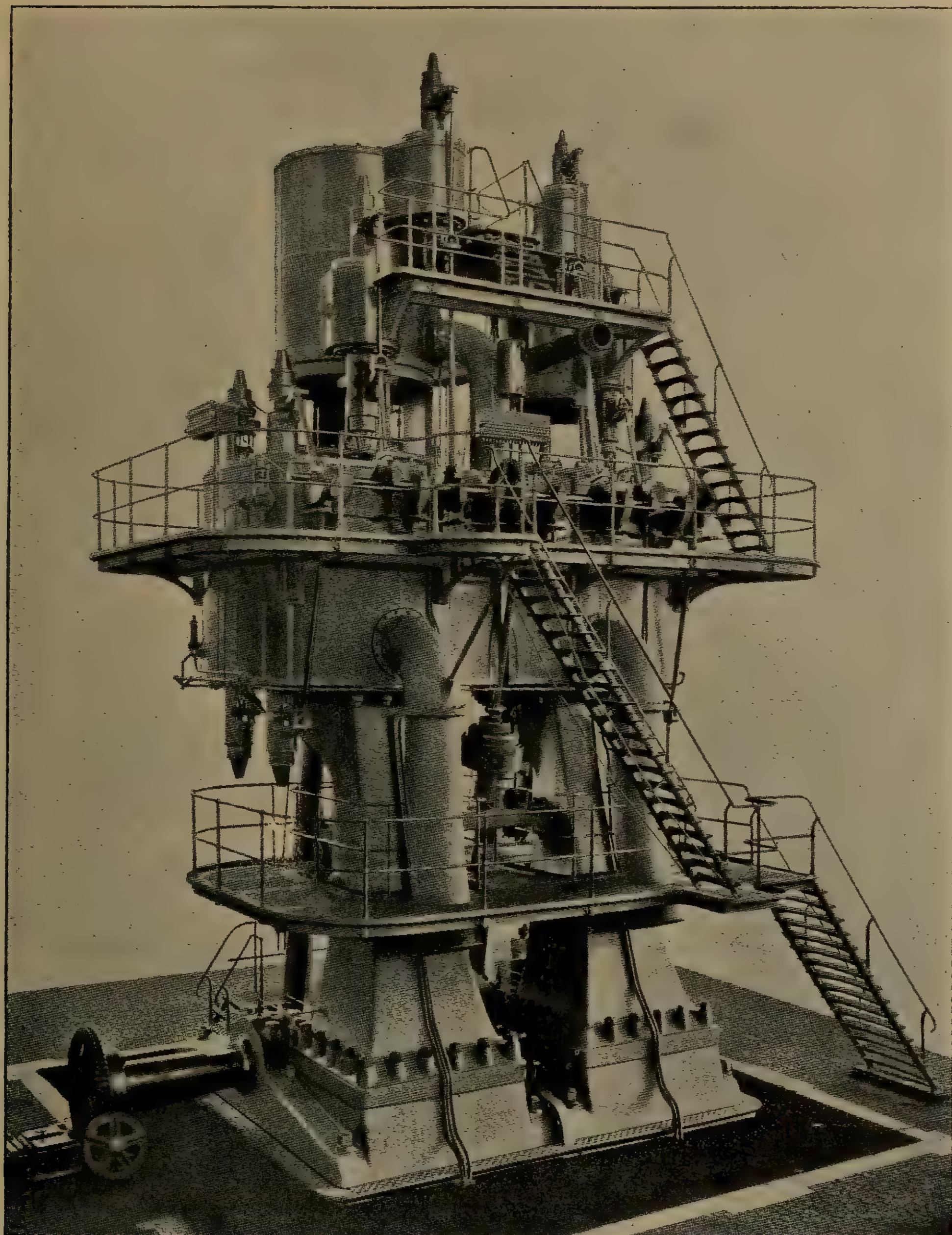
the top of the standards, and upon these, again, stood the "lanterns," or distance-pieces, of cast iron, strengthened in back and front by wrought iron columns; and upon the "lanterns," again, were erected the high and intermediate cylinders, accurate centrality throughout being ensured by this arrangement.

All the cylinders were provided with



TRIPLE EXPANSION, FOUR-CYLINDER, 2000 H. P. ENGINE BUILT BY A. BORSIG, BERLIN, GERMANY

liners, and were steam-jacketed, each jacket being heated by the working steam of its own cylinder. The " lanterns " above mentioned were so constructed that, by removing the wrought iron columns, the top covers and the pistons of the low-pressure cylinders could be taken out. The piston rods, after being uncoupled from their crossheads, could be dropped through holes in the bedplate, ordinarily closed by small covers, into cavities provided in the foundations, and could be then drawn out in an inclined position to clear the tops of the standards. The valve gear of all the cylinders was of the latest Collmann pattern, the valves being double-seated, and provided with oil dashpots. The valve casings were situated behind in the case of the high and intermediate cylinders, and at the sides of the low-pressure cylinders. All the valves were driven by eccentrics from a revolving shaft behind the low-pressure cylinders, carried by six bracket bearings. The motion was derived from the crank-shaft by bevel gearing through an inclined shaft between the standards, upon which the spring-loaded governor was fitted.



A REAR VIEW OF THE BORSIG ENGINE

The admission and exhaust valves of all the cylinders were actuated by trip gear, the release of the high-pressure admission valves being controlled by the governor, and the cut-off in the other valves being adjustable by hand. The oil dashpots of the new Collmann gear allow the valves to drop noiselessly upon their seats. In the high and intermediate gear the inlet and exhaust valves were driven by the same eccentric, while the valves of the low-pressure cylinders were each worked by a separate eccentric. The speed of the engine could be varied while running by means of a hand-wheel acting upon a spring in the oil dashpot of the governor.

The connecting rods were balanced in respect of their rotating mass by counterweights screwed to the crank webs, and were of the pattern usual in large marine engines. The piston rods were each made in one piece. At the front of the engine, a few steps above the bedplate, was a stage from which all the valve gear, and cocks, and other attachments could be worked. Between

the columns, on the edge of the second stage, there was a large name-plate, on which were also fixed the various gauges and a clock. A tachometer and a revolution counter were fixed to the left-hand column by a bracket.

All stuffing-boxes were lubricated under pressure. For the bearings and the rods two oil distributors were arranged upon the second stage, by which the oil gravitated from a cistern overhead, into which it was raised by a pump in the basement. The air-pumps derived their motion from a double-ended beam rocking upon two bearings fixed upon the air-pumps, and itself driven from a crank-pin in the disc on the end of the shaft, as already mentioned. All bearings and pins of the condensing plant were lubricated from an oil-distributor fixed to a cast iron column on the floor in front of the crank-shaft.

In the design of the engine the greatest care had been taken to make the oversight of all the parts as simple as possible, to ensure the greatest safety in working with a minimum of attendance. By means of the four stages or platforms and the staircases behind, all the parts of the engine could be conveniently reached.

The Société Française de Constructions Mécaniques, formerly J. F. Cail & Cie., exhibited a large compound, vertical engine, which, though of French manufacture, was easily recognisable as of American design, being a combination of the Allis engine, with Reynolds-Corliss valve gear, and the Thomson-Houston dynamo. The cylinders are 32 and 68 inches diameter by 48 inches stroke, working at seventy-five revolutions per minute. Although constructed for an initial pressure of 171 pounds per square inch, the dimensions were ample for furnishing the 1750 horse-power required by the 1000 kilowatt alternator with an initial pressure of only 128 pounds. This power is attained at the most economical point of cut-off; but, at the full pressure, with a 40 per cent. admission in the high-pressure cylinder and a 27½-inch vacuum, the makers calculate that this engine is equal to a duty of 3130 indicated horse-power. The method of construction and the general design of this engine depart widely,—so the makers say,—from the hitherto accepted practice. For large powers the use of vertical engines is a necessity, not only for mechanical reasons, but still more on account of the small space taken up, as compared with the horizontal type. The idea of the makers in adopting this design was to construct a vertical engine which should be as well adapted for electrical purposes as the horizontal class, and with this view they discarded the marine model which has hitherto served as the prototype for large vertical engines, and with it all the complexity due to the restricted space available on shipboard, but for which no reason exists in the case of a stationary engine.

As will be seen from the illustration on page 189, the engine consists essentially of two entirely independent pedestals, each of which has one of the two main bearings formed in one with it. Upon these, and serving as the supports for the cylinders, are two columns whose parabolic outline is that of the solid of equal resistance, forming at once the framework and the crosshead slides for each engine. The crank-shaft, 22 inches in diameter at the journals, is furnished with a cast-iron disc at each end, the crank-pins being set at right angles. The shaft carries, between the bearings, a fly-wheel of 24 feet diameter, weighing nearly sixty-nine tons. In addition to this there is the weight of the alternator wheel, amounting to over twenty-four tons. This arrangement, by the suppression of all intermediate bearings, realises for the vertical engine the advantages of the horizontal type.

The cylinders are fitted with Corliss valves, placed at the top and bottom, thus reducing the clearances to a minimum. The Reynolds-Corliss valve gear, of which the makers of the engine hold the sole manufacturing rights for France, is applied to both sets of admission valves, the governor controlling simultaneously the cut-off point in both cylinders for the purpose of equalising the power developed in each at all grades of expansion, as well as on ac-

count of the more accurate speed regulation attainable in this way. There is, in addition, a second governor which comes into action only when the speed exceeds the normal maximum. In case of any accident to the principal governor, this auxiliary is capable of entirely shutting off the supply of steam to the high-pressure cylinder. The latter is jacketed with boiler steam; the low-pressure jacket is supplied from the receiver, which consists of a number of small tubes surrounded by steam at boiler pressure, forming an efficient reheater.

The condensing plant consists of a vertical air-pump, driven by an independent engine, fitted, like the main engine, with Reynolds-Corliss valve gear, and supplied also with a safety governor. Although the greater part of this apparatus is below ground level, the steam cylinder and its valve gear are kept well within view of the attendant. The two platforms, with their staircases, give access to every part of the engine, and from the upper stage the action of both sets of valve gear can be observed simultaneously.

The international character of the Paris Exhibition was faithfully reflected in the diversity of types of vertical engine on view in the Palace of Electricity. It would be hardly possible to bring together five engines embodying more points of difference in structure and in design.

The engine of F. Ringhoffer, of Smichew, Prague, shown on page 188, was a four-cylinder, triple-expansion vertical, arranged as a double tandem, with the peculiarity that the high-pressure cylinder, instead of the low, was divided in two. The engine was intended for a normal load of 1600 indicated horse-power, and a maximum of 2000 I. H. P., with 189 pounds pressure, at ninety-five revolutions per minute, driving a continuous-current dynamo, which gave 1800 ampères at 550 volts. The dimensions are as follows—:

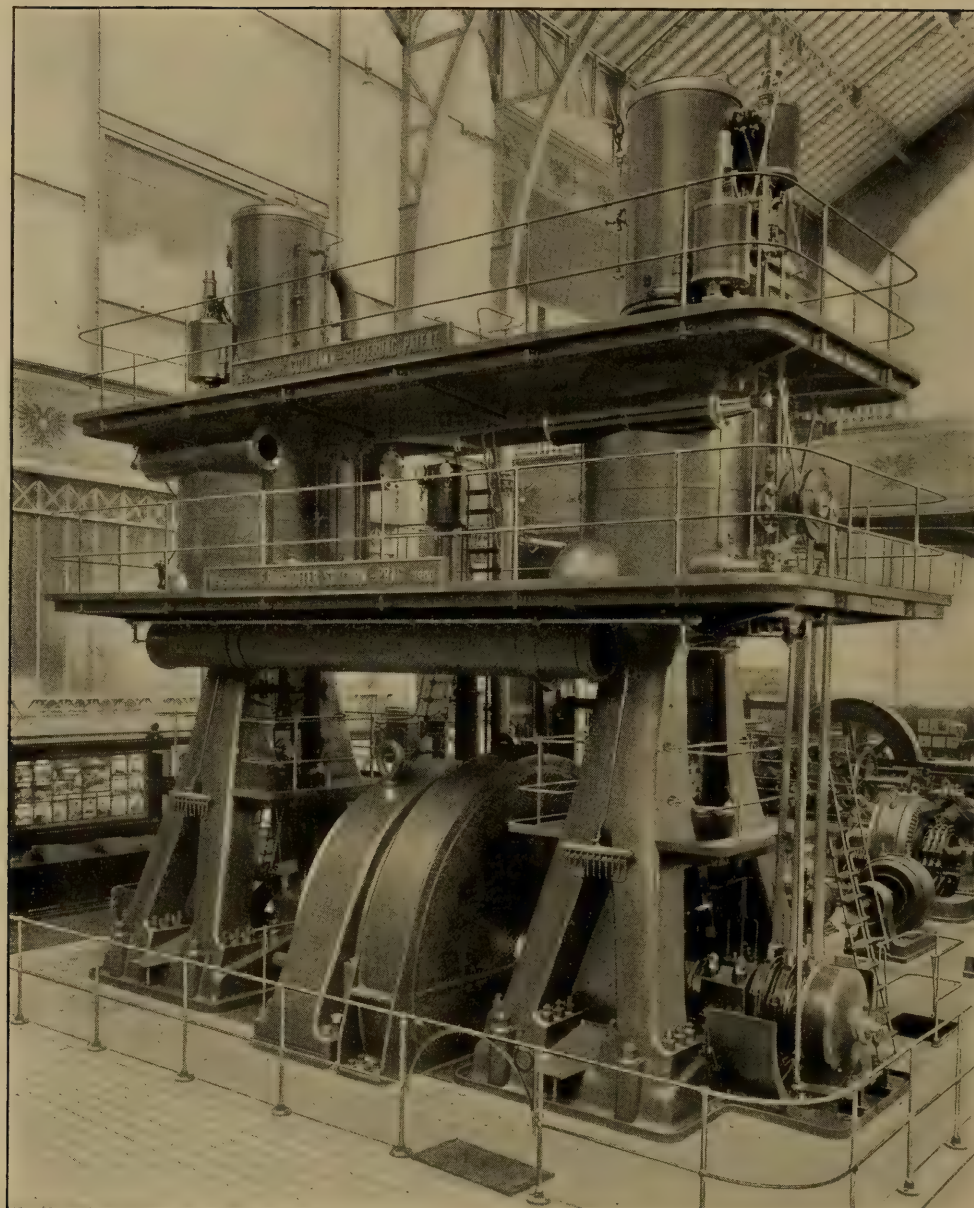
Diameter of high-pressure cylinders (two)	21⅝ in.
Diameter of intermediate cylinder	45⅜ in.
Diameter of low-pressure cylinder	65 in.

The stroke of all the cylinders was 35⅜ inches. The intermediate cylinder and one of the high-pressure cylinders were placed on the right; the low-pressure and the other high-pressure cylinder, on the left. Each side had its own double-armed crank, coupled to the dynamo shaft placed between. The cranks were placed 90° apart, the low-pressure crank leading.

The maker gives the following reasons for adopting the plan of dividing the high-pressure cylinder, and it is interesting to compare these with the arguments adduced by the Augsburg-Nürnberg Company in favour of dividing the low-pressure cylinder, as carried out in their horizontal engine, shown on page 180. Some of the reasons in either case seem a little shadowy. In the present instance the advantages claimed are:—"Smaller valves,—hence more suitable for use with superheated steam; lessened stress upon the reciprocating parts. It is the high-pressure cylinder which suffers instant changes of load as the cut-off varies, and these are distributed over both cranks, instead of upon the high-pressure side only. The governing, for the same reason, is exceptionally accurate, the regulation of the cut-off point occurring four times per revolution, instead of twice. The turning effort is also more uniform; and, lastly, the stability of the engine is improved by the relative smallness and lightness of the upper cylinders."

The high-pressure cylinders are fitted, for both exhaust and admission, with double-seated lifting valves and the Collmann gear. All four valves for each cylinder are driven by a single eccentric, the range of cut-off being from 0 to 70 per cent. In the exhaust gear the triggers are moved by an auxiliary rod deriving its motion from a point in the disc of the Corliss gear of the intermediate or the low-pressure cylinder beneath in such a manner that the degree of compression can be altered at will. The speed is regulated by a drum governor, shown on the end of the crank-shaft.

The intermediate and low-pressure cylinders are furnished with circular valves having a continuous movement, driven in the first-named case by sepa-



FOUR-CYLINDER TRIPLE EXPANSION ENGINE BUILT BY F. RINGHOFFER, SMICHEW, PRAGUE

rate eccentrics for admission and exhaust, both being adjustable by hand. In the low-pressure gear the four valves are worked from a Corliss disc, driven by a crank-pin fixed at the further extremity of the crank-shaft, the use of toothed gearing in any part of the valve gear or governor being entirely avoided. All the valve gear is placed on the outer sides of the engine to protect the dynamo, as far as possible, from accidental splashings of oil.

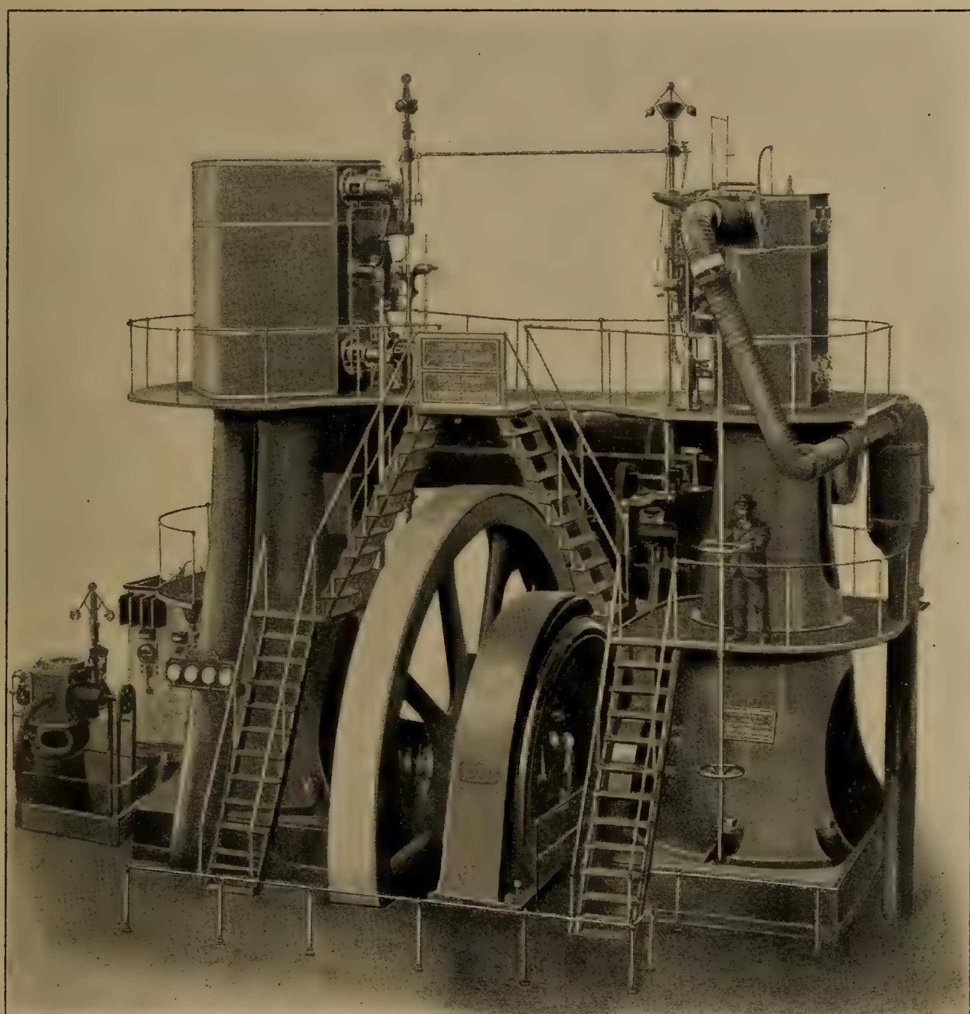
The two halves of the bedplate each carry two plummer blocks. The bearings are of cast steel, lined with white metal. A groove or moulding surrounds the bedplate for catching the waste oil. The standards, of the pattern now used in large marine engines, are each in two parts, for convenience in handling and transport. The crosshead guides are concave; the crossheads are of cast steel, with adjustable slippers faced with white metal; and the crosshead pins are of steel, case-hardened, ground, and polished.

The connecting rods have their large ends made on the marine pattern, the small ends being solid and adjustable by cotters. Only the high-pressure cylinders are steam jacketed. The standards are united by strong cast iron gird-

ers, which also serve to carry the lower platform. Similar girders extend from the low-pressure to the intermediate cylinder and support the upper platform. Smaller platforms at a lower level give convenient access to the crossheads and slides.

The main bearings, crank-pins, cross-head-pins and guides are all lubricated from a central oil distributing arrangement, supplied from a cistern on the central gallery. The waste oil is caught in the hollows of the bedplate, passed through two filters in the basement, and is pumped up again. The two condensers and air-pumps are disposed below ground. The air-pumps are vertical and double-acting, their motion being taken from the engine crossheads by means of wrought iron double-ended levers and rods. The consumption of steam, with a pressure of about 170 pounds per square inch and 630° to 650° Fahr. of superheat, is guaranteed not to exceed 9.7 pounds per indicated horse-power per hour. There was no opportunity of verifying this, but the engine certainly did run with great regularity and without perceptible jar in any part. The workmanship also was, to all appearance, faultless.

Another exceedingly well-finished vertical engine was shown by the Société Alsacienne de Constructions Mécaniques, of Belfort. An illustration of this is given on page 179. It was a two-crank compound, with cylinders 33½ and 53¼ inches in diameter, by 4 feet stroke, running at seventy-five revolutions per minute. There are six main bearings, giving an aggregate length of more than 11 feet, with a diameter of



COMPOUND ENGINE BUILT BY LA SOCIÉTÉ FRANCAISE DE CONSTRUCTIONS MÉCANIQUES, PARIS

13¾ inches. The cranks are placed 180° apart, and are not counter-weighted, each engine balancing the other. On account of the nearness of the cranks the "rocking couple" is nearly eliminated, and the engine ran with remarkable steadiness. The total length of the crank-shaft is no less than 29 feet 6 inches, made in two parts united by a central coupling, each half weighing, finished, about five tons.

The main bearings are of cast iron, lined with white metal, and are internally cored to form water passages for cooling, should this be required. As will be seen, the dynamo and the fly-wheel are upon opposite sides of the engine, about 18 feet apart. The fly-wheel is 18¾ feet in diameter and weighs over thirty tons, the weight of the armature being about nineteen tons.

In construction this engine contrasts strongly with that of the Société Française, shown on page 189, and their remarks anent the use of the marine type of vertical engine for electrical purposes might be properly re introduced here. The connecting-rods are of steel, the large ends being of the marine pattern with through bolts and circular brasses; the small ends are solid, with wedge adjustment.

The bedplate is a deep and massive box casting, in two parts, securely bolted together, the outside bearings being, of course, carried on separate foundations. The main standards are each in two parts, with bored-out guide surfaces, both pairs of standards being united at the top, just beneath the cylinders. In an engine so admirably finished as this one was, it was to be regretted that the makers did not spend a little more money on the patterns of the standards by filling in the broken backed outline which detracted from the otherwise graceful appearance of the structure. A gallery surrounds the base of the cylinders, giving convenient access to the valve motions. The cylinders are each jacketed with their working steam, *i. e.*, the high-pressure by boiler steam, the low by steam at receiver pressure. The valves and gears are Corliss throughout. The illustration of the engine shows clearly the arrangement of the low-pressure gear, which is worked by a single eccentric, the Corliss disc being replaced, as is not unusual in Continental engines, by a cross-armed wrist-plate. On the high-pressure side the admission and exhaust valves are separately driven by two eccentrics. The spring-loaded governor is driven by chain gearing, and controls the cut-off in the high-pressure cylinder by a remarkably simple trip-motion, of which it can only be said here that it is the embodiment of common sense in valve-gear design, and should afford a useful lesson to the designers of some of the Exhibition valve gears. Ample relief valves are provided at the top and at the bottom of each cylinder. The condenser is of the vertical bucket type, the movement of the water being continuously upward, through the suction, bucket, and outlet valves. It was, as usual, below ground level, and was worked by double armed levers from the high-pressure crosshead.

With a 26-inch vacuum and steam at 88 pounds initial pressure, cut-off at 25 per cent. in the high-pressure cylinder, this engine is good for 1250 indicated horse power, the steam consumption being about 14½ pounds per indicated horse-power per hour. The efficiency of the engine itself, or $\frac{\text{B. H. P.}}{\text{I. H. P.}}$, was given as 88 per cent.

The same firm exhibited a 300 H. P. horizontal, cross-compound Corliss engine. In any other situation this well-designed and admirably finished engine would claim a detailed description, but in the Palace of Electricity a 300 H. P. engine was a minnow among Tritons, and must give place to more important examples.

STEEL SHIPS WITH PROTECTED BOTTOMS

DESIGNED FOR ECONOMICAL REPAIRING

By Joseph R. Oldham, N. A.

PERHAPS the most appalling and disastrous shipwrecks resulting from impact with rocks of which there is any authentic record were those of the iron mail steamers *Atlantic*, at Marshead, near Halifax, N. S., in 1873, and *Drummond Castle*, off the coast of Spain, in 1896. These steamers had neither double iron bottoms nor wood sheathing, and of the larger of the two, the *Atlantic*, it may be said, and the statement now appears somewhat startling, that though of excellent construction, there were but three-fourths of an inch of iron bottom plating between the five hundred and forty-six souls lost on that ill-fated steamer and a ruthless ocean. The writer is led to recall these disasters because of his conviction that vessels employed as these were should have much greater protection from fatal injury than is usually provided.

There are two ways of protecting vessels, at least partially, from such injuries as caused the losses above referred to, and both means may be incorporated in the same structure. The bottom of a ship may be protected from the effects of grounding by a strong, continuous upper bottom, connected to the sides at the upper turn of bilge, or it may be protected, probably in a lesser degree, by a strong lower bottom formed of teakwood or rock-elm, and when these safeguards are combined with efficient subdivision of holds and bottom, the good ship should be thoroughly worthy to carry passengers and goods of the greatest value. Moreover, such protection is not too much to ask of those who acquire a license for the conveyance of women and children over the seas and oceans. With this brief preface, the writer will endeavour to show that such protection is real; that it need not be expensive; and that strong sheathing will greatly lessen the cost of bottom repairs.

Speaking generally and comparatively, the writer would say that while the bottoms of ocean steamers should be made for floating, the bottoms of vessels plying on waters like the Great Lakes, in the United States, should be designed with a view to grounding. Though it is the exception to find large steamers engaged in the North Atlantic foreign trade without signs of distress at the bilge and bottom plating, due to afloat stresses, it is the rule with vessels on the Great American Lakes. From this it might be inferred that the bottoms of such large lake steamers are generally stronger than similar ocean vessels, and if it is permissible to consider the combination of the upper and lower bottoms as forming one member, the inference may be considered correct, as the upper bottoms of these lake vessels are very much heavier and stronger than specified by any of the great classification rules, and the tendency is to even augment the strength in the Lake practice in the United States. That being the case with regard to the upper bottom, it would seem that a considerable reduction of weight might safely be made in the lower steel bottom, and this, in connection with other proposals, is the point

to which the writer desires mainly to draw attention.

Many years ago, Professor Moseley stated that the strongest form that can be given to a solid body, in the formation of which a given quantity of material is to be used and to which the strain is to be applied under given circumstances, is that form which renders it equally liable to rupture at every point, so that when, by increasing the strain to its utmost limit, the solid is brought into a state bordering upon rupture at any one point, it may be in the state bordering upon rupture at every other point. Hence, it follows that the solid constructed of the strongest form with a given quantity of material is evidently that which can be constructed of the same strength with the least material, so that the strongest form is also the form of the greatest economy of material.

On the Great American Lakes there are large steel vessels with heavy steel bottoms sheathed with four or five inches of oak, and this double lower bottom is further protected by a continuous steel upper bottom These vessels are mainly held together at the top by stringer plates not larger than 72″ × 8-16″. Surely, there is a redundancy of strength in the bottoms of such craft, and the arrangement of material appears to be the very antithesis of Professor Moseley's ideal. Though this is an extreme example of unequal distribution of materials in ship construction, the writer is inclined to the opinion that in comparison with ocean steamers the difference is more largely one of degree than of fact.

For many years the writer was intimately associated with the construction and repairing of the largest ocean steamers, and though the bottoms often showed clear indications of disturbance through the butts, being occasionally slightly strained and always largely over-calked, it was the topsides and stringer plates that caused most anxiety, at least in steamers engaged in the North Atlantic. Therefore, it seems that in continuous double-bottom steamers a much larger reduction than is usual could safely be made in the thickness of the lower bottom, when it is well sheathed, without raising the neutral axis too high. As regards the strength contributed by a wood bottom in connection with steel, experiments have proved that so long as the stresses put upon the metal do not surpass the limits of elasticity of the wood, elm or oak will act with steel and lend it valuable assistance even in resisting longitudinal bending.

To ascertain the strength of a structure it is essential that the stresses which it is to encounter be known, as well as the material of which it is composed. The one is a measure of the tenacity required; the other, of the tenacity possessed; and the strength depends upon the relative proportions of the two. The ever-varying forces, however, which act upon a ship when working in a seaway, cannot be defined with mathematical accuracy, and it is still more difficult to determine the stresses to which the structure may be subjected when the bottom is brought into violent contact with rocks or hard, uneven ground; but fortunately at this time there is available a large fund of experimental data, which is more valuable when carefully analysed by the scientific shipbuilder or engineer than the most elaborate formulæ based on purely theoretical deductions, and it is safe to say that all genuine high-class vessels have a large factor of safety in the bottom for resisting "afloat" stresses.

With regard to the tenacity of wood, Professor Rankine proposed to take 5½ tons as the average ultimate tensile strength of shipbuilding wood. This average appears high for oak, though Cotterill and Slade give 6.7 and 4.4 tons, respectively, as the ultimate tensile and compressive strengths of oak. Templeton found the tenacity to be 5.9 tons, and resistance to compression, 4.75 tons. Sir W. H. White found these strengths to be from 4 to 4½ tons, but he adds:—"More recent experiments would indicate that this is too high an estimate, and that a fairer one would be about 3 tons per square inch."

These figures give a very wide range of tenacity, as they show oak or rock-elm to be from about one-fourth to one-tenth of the tensile strength of steel. The comparative resilience of oak is given as 64; elm, 86; teak, 94.

Rankine found the modulus of elasticity of oak to be 1,900,000, while steel has a modulus of 29,000,000, representing a ratio of about 1 to 15, but for computing the local bending of bottom plates or plank so conditioned, no reliable formulæ has yet been constructed; hence, we must depend largely upon experimental knowledge.

In 1893, at the International Engineering Congress, the writer suggested the advisability of sheathing the bottoms of warships with wood, and, as an instance of the benefits of such protection, cited the cases of a steel and an oak steamer being stranded together under identical conditions which showed that while the wood bottom was practically uninjured, the injuries to the steel bottom cost $5000 (£1000) to repair. The thickness of the oak bottom was 5 inches, and of the steel bottom half an inch, the wood thus being ten times the thickness of the steel. From this example and many similar ones, it will be safe to conclude that an oak or a rock-elm bottom 5 inches thick is vastly superior, as regards resilience, to a steel plate one-tenth of that thickness. Thus it appears that when an ordinary steel bottom is sheathed with elm the general strength of the bottom or lower member is about doubled. It is, therefore, not surprising to hear that the cost of sheathing and coppering often amounts to 3 per cent. of the cost of the ship.

Suppose, however, that instead of fitting two lower shells of full thickness in addition to a strong upper bottom, the lower steel skin were reduced 50 per cent., which could be done without danger in large vessels when well cemented inside and thickly planked outside; then it would be found that the sheathed ship would cost no more per ton displacement than the unprotected ship of equal strength. As regards decreased resistance to buckling due to thinner plating, this is more than compensated by the thick plank. Referring to the perforation of ships' plates, Sir Nathaniel Barnaby has said:—"Security against risks of fatal disaster depends very little, if at all, upon the thickness of the bottom plating or the closeness of the ribs. The advantage of a steel plating of one inch in thickness over another of half an inch would be very doubtful, and closeness of frame spacing is not much more valuable."

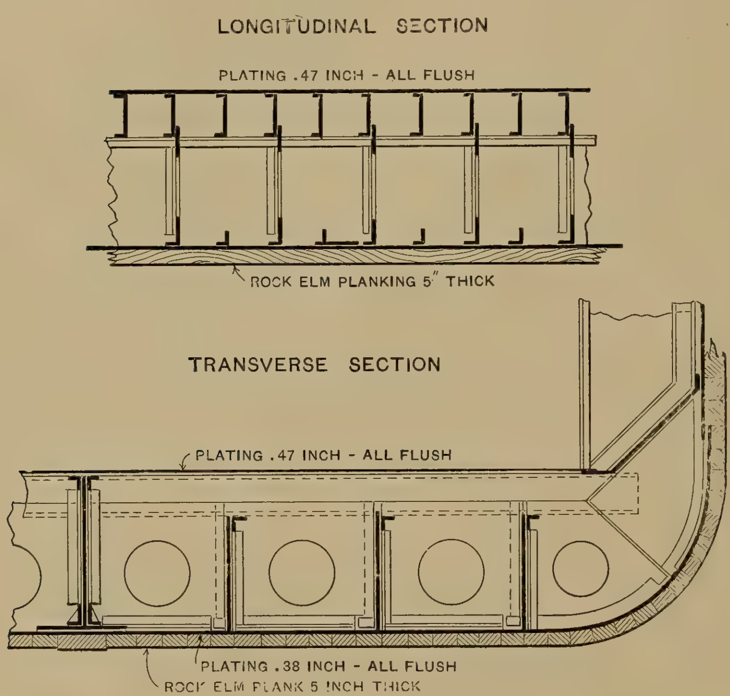
Provided the bottom be sufficiently strong to resist the bending moment of hogging and sagging stresses, and the lightest well-constructed bottoms are capable of this, ⅜-inch bottom plating, with the addition of 5 or 6-inch planking and a modern upper steel bottom, would be amply strong for the largest ships. One reason for the writer's advocacy of thick planking is, that the thicker the elm, the smaller will be the weight ratio of bolts, nuts and metal; indeed, the finished weight of the sheathing need not exceed its displacement. Steel vessels with sheathed bottoms and those of composite construction are seldom seen in dry dock for repair, and notwithstanding the severe bottom injuries often received by purely steel vessels, their strong upper bottoms have always kept them safely afloat.

Bearing on this subject the writer would point out that for protecting other parts of steel hulls, wood has proved more efficient than various sections of steel, for when wooden plank is subjected to percussive action, the blow is gradually absorbed, and the much greater thickness of an oak plank over a steel plate provides a more elastic cushion. In the case of coasting vessels, which suffer severe wear and tear by frequent impact with piers and dock walls, protection has been sought by arming the sides with thick, flat plate fenders, and also with strong hollow steel fenders, which, by the way, have been filled in with pine; but after a most patient and careful trial, these have all been abandoned in favour of the old-fashioned and more flexible oak fenders.

No more need be said to show that wood sheathing largely increases the safety of a ship in the event of collision

or stranding, and that wood also protects the sides in a fuller degree than steel fenders of any form. But this was not the leading idea with those who first proposed the sheathing of iron vessels. The object they had in view, of course, was to form a base to which copper or yellow metal could be nailed without injury to the iron shell.

The approved manner of fitting the shell plating in ordinary steamers is to arrange the plates in inside and outside strakes alternately, though, in very long vessels, the shipbuilder invariably resorts to flush, or edge-to-edge plating,—frequently in connection with doubling plates, it is true,—to secure longitudinal strength.



RAISED FLOOR, FLUSH PLATED BOTTOM CONSTRUCTION

With ductile mild steel it will frequently be observed that for one fractured plate in the bottom of a vessel that has grounded there will be found about ten times as many plates not fractured, but only severely indented. What the writer would define as a severe indentation is above 1½ inches in a diameter of 20 inches. Indentations exceeding this ratio without fracture are not uncommon, however, and as local heating of steel " in place," without removal for annealing, is a very hazardous and make shift practice, it becomes necessary to take out such damaged plates to be warmed, rolled and annealed. If they happen to be in an inside strake, the consequential damages are large, for when an inside plate has to be removed, the riveting and calking of at least two outside plates must also be renewed. Flush plating generally entails a difficulty with regard to liners, unless the longitudinal strap be an outside one, when the obstruction would equal the remedy suggested; but with a strong upper bottom, having ample transverse strength, a safe and practicable arrangement may be designed for a flush bottom, with single-riveted seams joined by an inside strap without liners. No harm need be apprehended with such bottoms in deep water, and as to excessive damage by grounding, let us examine the conditions!

When a vessel of about ten thousand tons displacement strikes the ground with a velocity, say, of 17 feet per second, the result to the plating will be practically the same whether the plates be arranged in and out and double-riveted, or flush and single-riveted, provided the longitudinal straps in the latter case be broad and strong; for, with a kinetic energy of 45,000 foot-tons, the lower bottom must succumb where locally pressed till sufficient surface comes in contact with the ground to avert further fracture or permanent set. If the bottom were all double-riveted, the rivets in damaged plates would be either sheared or strained beyond the elastic limit, and single-riveting could not suffer much worse. The writer would make it clear, however, that he does not propose any diminution of the riveting of the bilge and sides, nor of the fore-foot and heel. His suggestions with regard to less elaborate riveting in connection with flush plating are limited to the longitudinal seams, and

to them only over the flat bottom. The careful designer of a ship or of the machinery within her will keep in view the probability of certain portions of such fabrics requiring extensive repairs or partial renewals from time to time, and he will accordingly arrange details, within certain economical limits, so that the structure may be readily repaired without destruction or disturbance of other large portions of the hull or machinery. On the inland seas of the United States half the average voyage is in comparatively shallow water, in many parts of which narrow and tortuous rivers must be navigated; the consequence is that groundings and collisions are more frequent than in the principal ocean trades. Therefore, the bottoms of such lake steamers should be constructed largely to resist percussive stresses.

If the bottom is to be sheathed, closer work and better plank fastening may be secured with flush plating than with lap-jointed plates. This is an incidental advantage of edge-to-edge plating, but the object of the design illustrated on the opposite page, was to eliminate what the writer would call consequential damages when repairing local injuries. With the old system of framing and plating there would have been a difficulty in placing the longitudinal girders with the transverse floors above; but as the bottom plating is now first fitted on blocks or shores, the raised floors and upper bottom may be placed on the fore-and-aft girders without loss of time or labour. By thus fitting deep floor bars directly beneath the upper bottom, as illustrated, the plates will, no doubt, be sufficiently rigid without oak ceiling to withstand the impact of the heaviest ore buckets, for example, in American Lake service, when descending at maximum speed, and be amply strong to float the vessel to a dry dock anywhere.

The idea of coppering the bottoms of iron vessels is an old one. When a student in naval architecture, the writer remembers an ingenious gentleman exhibiting his patent for protecting the bottoms of iron vessels. The device consisted in leaving the butts and landings of the plating about half an inch open. Into these crevices strips of teak wood were forced, and the yellow metal was nailed onto the strips of wood. This is not cited as a pattern for imitation, but rather as an example to deter. The sheathing for salt water service should be fastened with galvanised bolts and nuts, the bolts having white-leaded grummets under the heads covered with turned dowels, carefully fitted and bedded in white lead.

As a remedy for fouling, bottom sheathing and yellow metal have been extensively adopted by the German, French, British, and Japanese governments, and the most eminent and successful constructors of the present and former days have recommended the coppering of warships. The Russian Admiralty also earnestly advocates sheathed ships, having found no paint with satisfactory anti-fouling properties and having little faith in the brushes employed by some inventor for cleaning bottoms afloat, which scrub off the paint with the weeds and barnacles.

These speculations of ingenuity remind the writer of an expedient often resorted to in the Mediterranean trade. When the bottom of a steamer was too foul to make another trip, say to Italy or Egypt, she would be sent to the Baltic, and that would make the bottom perfectly clean; indeed, so clean that it soon required painting to prevent corrosion and pitting. This inspires the thought that a Russian or German fleet in the Baltic could become clean without docking, when a hostile, unsheathed fleet coming from other seas might be rendered helpless through the bottoms being foul.

If there were a reliable paint to be had that would keep foreign growth off the steel and also prevent corrosion or pitting, there would not be any great necessity for coppering the bottoms of steel vessels; but those who have had experience in the working of ships, trading to the Orient, for instance, know that this is still far from realisation. In the writer's experience, it often appeared that the anti-corrosive paint did not prevent corrosion, and the anti-

fouling coat failed to prevent fouling for any great length of time at least; hence, the necessity for coppering.

Several years ago the writer was connected with the engine department of a line of steamers trading between European ports and Manila, and remembers that these vessels required docking, cleaning, and coating every voyage. This was also the practice with Holt's tea ships and other fleets, and keen was the competition to secure the order for cleaning and coating these bottoms. It was no uncommon thing for a representative of a patent composition to place his article in competition with a rival paint by coating one side of the bottom, or even a portion of it, to show the superiority of its anti-fouling qualities. An acquaintance who was very enthusiastic over the superior merits of his composition, painted the port bottom of a certain vessel, and on her return from an eastern voyage, and before she entered the dry dock, he invited the ship owners of the locality to take a trip down the river to a summer resort near the dock and see for themselves the superior value of such an article as he sold But when the dock was pumped out, the starboard bottom was seen to be almost clean after a four-months' voyage, while the port bottom, which had been coated with his composition, was thickly covered with barnacles and long green grass. This is no romance, and similar results may have been seen by many.

As good plank is not plentiful in all parts of the world, it may not be advisable to sheath steamers intended for the Baltic or North Atlantic trades, where large dry docks are usually available; but with good rock-elm at hand, it might still be fitted to large passenger steamers with advantage.

The conclusions to which the foregoing investigations have brought the writer are, first, that cruisers and other sea-going warships should be sheathed to protect them from fatal injury by collision with rocks or ships, and also to permit of coppering. Second, that lake vessels intended for winter trading on salt water should be sheathed to protect them from grounding injury while trading on the lakes, and also to facilitate coppering for the foreign trade.

COKE-MAKING IN THE UNITED STATES

DATA FROM THE FAMOUS CONNELLSVILLE REGION

By William Gilbert Irwin

A COKE DRAWER

IN the rise of the iron and steel industries to their present greatness there has been no more important factor than coal, and when some future Gibbons or Macaulay shall rise to proclaim the honours won by mankind in the peaceful fields of industry, the development of the great coking industry shall form one of the most interesting chapters in such annals.

While the effects of the rise of the coke industry have been universal, it was in western Pennsylvania that the industry was earliest characterised by success, for it shifted to this section the early pig iron industry of the United States, and thus gave Pittsburgh her lead in iron-making which she has retained to the present time. Sixty years ago there were only two or three pig iron furnaces in that part of Pennsylvania, while to-day the iron and steel interests of Pittsburgh command attention in all parts of the world.

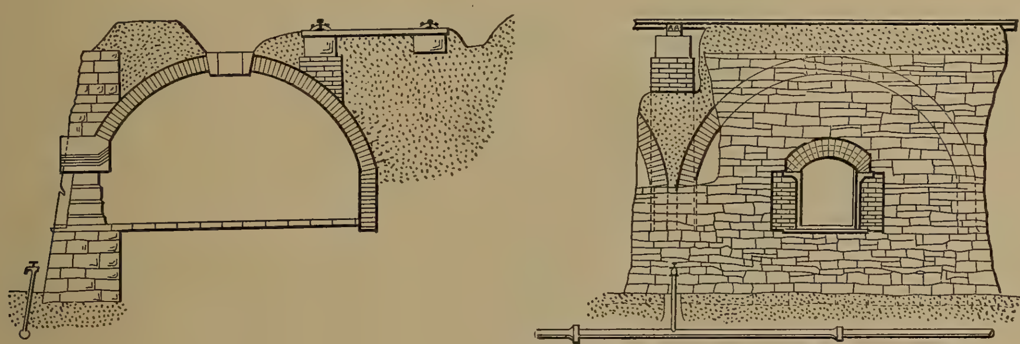
While the successful manufacture of coke may be said to be confined to a comparatively recent period, the process is no newly discovered one. As early as 1735 coke was successfully made in England, and it was in use in the blast furnaces of that country as early as 1750. The first rolling mill in western Pennsylvania was built at Plumsock, in Fayette County, at present the heart of the Connellsville coke region, and in 1817 an attempt was made to use a kind of coke there. Its use was attempted with little success near Pittsburgh two years later, but it was not until years afterwards that the superior qualities of this form of furnace and foundry fuel became known.

The credit for interesting the Franklin Institute, of Philadelphia, in the fuel belongs to F. H. Oliphant, a pioneer furnace owner of western Pennsylvania, who took specimens of ore which he had smelted in his furnace at Fairchance, in Fayette County, and exhibited them before that society, at the same time exhibiting specimens of the coke which he had introduced at his plant and with which the iron had been smelted. As a result the society offered a premium to the person who should manufacture the greatest amount of iron using the new fuel, the amount not to be less than twenty tons. On January 16, 1836, the legislature of Pennsylvania passed an act to encourage the manufacture of iron with coke and coal. In 1835 grey forge iron was successfully made in Huntingdon County, Pennsylvania, with coke as a fuel, and from 1836 to 1839 a number of but partially successful trials at iron-making with the new fuel were made at various points in western Pennsylvania.

In the early attempts at coke-making the coal was coked in open ricks on the ground, and no ovens were built until some years later. But whether or not the coal of the Connellsville seam is coked in ovens, the results should be good. It is a natural coking coal, and the bee-hive type of oven in general use throughout this great coke region at the present day, so far as concerns the chemical enrichment of the product, represents but little improvement over the primitive methods used in the production of the first coke manufactured

THE MOREWOOD, PA., PLANT OF THE H. C. FRICK COKE COMPANY

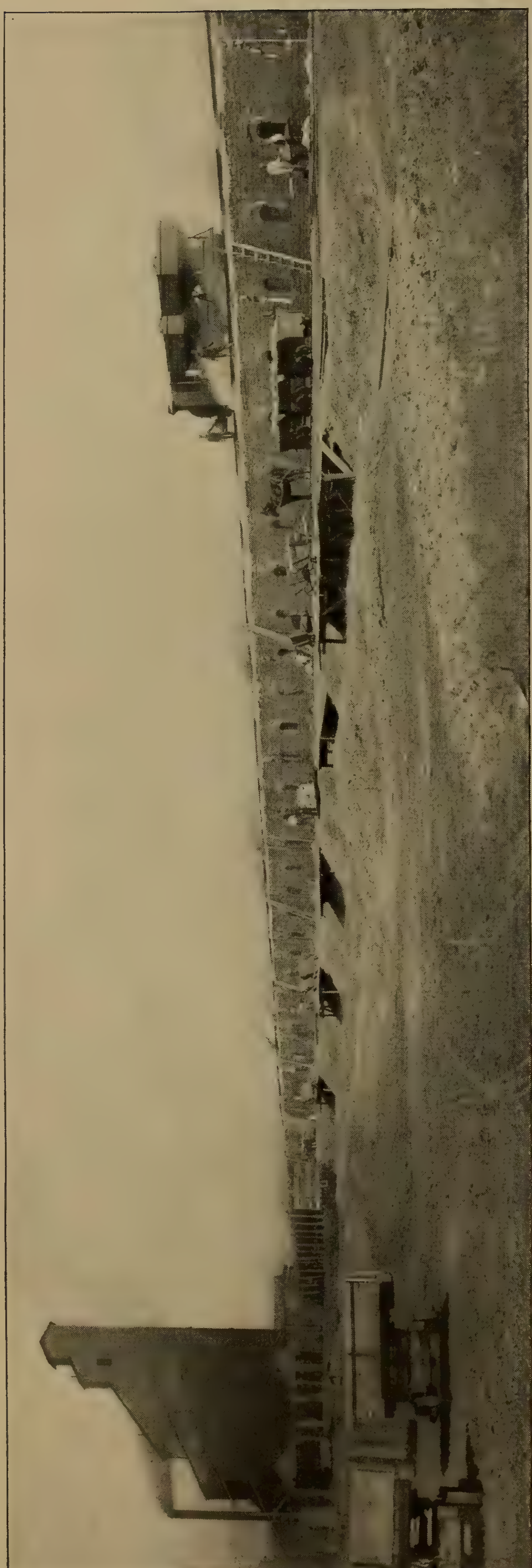
there. Passing over these earliest attempts at coke-making, including the unverified statement that the product was used at the Allegheny furnace, in Blair County, Pennsylvania, in 1811, and the operation of Oliphant's Fairchance furnace from 1835 to 1840 using coke as a fuel, which latter, in a small degree, is correct, we find that James Campbell, Provance McCormick and John Taylor, the latter a stone-mason and the owner of a farm on the Youghiogheny River a few miles below Connellsville, erected two ovens at this point and began the manufacture of coke in the winter of 1841. This was the first attempt ever made in the United States to make coke in ovens. Aside from the fact that they were considerably smaller in size, these primitive ovens did not differ materially from those in general use in the Connellsville region and elsewhere at this time. They were of the bee-hive pattern, with a fourteen-inch rise and a flat crown, and held sixty-five bushels of raw coal. Their construction presented many difficulties to those pioneer coke-makers. At first they had no draught, nor did they hold a sufficient body of coal to produce a good quality of coke. Finally, after many changes and alterations, the two ovens were put into successful operation, and by the spring of 1842 enough of the new fuel had been made to load a 90-foot flatboat, and at the first rise in the river the cargo was floated and rafted down the Youghiogheny, Monongahela and Ohio rivers to Cincinnati, where a market was vainly sought for it.



SECTION AND ELEVATION OF A BEE-HIVE COKE OVEN

Then came a decided reverse for these pioneer coke-makers. To the iron-makers of Cincinnati coke was a new product and they called it "cinders," refusing to purchase or attempt its use in their furnaces. Samples of the product were hawked about the streets of the city in coffee sacks, and finally a purchaser was found in the person of Miles Greenwood, a wealthy foundryman, who agreed to pay six and one-fourth cents per bushel for part of the cargo. Finally several canal boats laden with the product were taken to Dayton, Ohio, and sold to Judge Gephart, who operated a furnace there. The latter recognised the value of the coke and soon came to Connellsville to induce Taylor and his associates to produce more of the article. They, however, could not be prevailed upon to continue what had been to them a losing venture.

In the autumn of 1842 Mordecai James and Sample Cochran, the latter the father of the operators of a large number of coke plants in that region in later years, leased the two ovens from the owners, and their efforts at coke-making proved a decided success. About this time, when they had coked about 1800 bushels, it was taken to Cincinnati and sold to Miles Greenwood, who, in the meanwhile, had become acquainted with the value of coke as a fuel. About this time also Richard Brookins erected five ovens on the opposite side of the Youghiogheny. In 1850 Stewart Strickler built four ovens in the Connellsville region and disposed of the product in Cincinnati. For some years little coke was made in western



BLOCK OVENS AND COKE CRUSHER PLANT IN THE CONNELLSVILLE REGION

Pennsylvania, but this was the period of experiment and education for the coke industry, and soon the pioneer efforts bore abundant fruit. In 1855 there were only twenty-six ovens in operation in the Connellsville region.

It was not until the completion of the Baltimore & Ohio Railroad through the Connellsville region and the establishment of railroad communication with Pittsburgh and other manufacturing centres that the coke industry began to give real evidence of success. In 1859 Graff, Bennett & Co., of Pittsburgh, began the use of coke in their Clinton furnace, and this pioneer furnace use of coke in Pittsburgh proved highly successful. From this time the steady growth of the coke trade can be dated. About 1860 the Fayette Coke Works, a plant of thirty ovens, were put in operation, and from this the supply for the Clinton furnace was obtained. In 1864 forty ovens were built on Hickman Run, in Fayette County. Previous to this, however, the Connellsville Gas, Coal & Coke Company had been organised and had erected forty ovens near Connellsville. In 1869 forty ovens were built near Dunbar, in Fayette County.

The United States Census reports for 1850 show that there were then only four coke-making establishments in the United States and that all of these were located in the Connellsville region. In 1860 the number had increased to twenty-one, while in 1870 there were twenty-five coke-making firms, although the number of plants exceeded that figure, some of the firms operating several of them. The census returns for 1850 and 1860 show that all the coke produced in the United States at that time

was manufactured in the Connellsville region, while in 1870 92 per cent. of the country's production was furnished by this region.

Between the years of 1870 and 1880 the coke industry began to assume a commanding position in the industrial world. It was in the year 1871 that the H. C. Frick Coke Company, which now controls the output of the Connellsville region, came into existence, and the story of its progress is really that of the entire Connellsville region. In the year 1871 the Mt. Pleasant & Bradford Railroad, of which H. C. Frick was president, was constructed, and thus new railroad facilities were presented in the Connellsville region. At the same time H. C. Frick, A. O. Tinsman and Joseph Rist associated themselves to engage in the coke business. They secured 300 acres of land near Mt. Pleasant and erected a plant of 50 ovens, known as the "Frick Works." In 1872 fifty ovens were added to this plant, and the firm built the Henry Clay Works of 100 ovens on the Youghiogheny River near Broadford. In the same year other concerns erected plants at Mt. Braddock, Jimtown and Valley, in the Connellsville region, and oven-building continued until, in 1873, there were 3673 ovens in the Connellsville region. Then occurred the panic of 1873, and the coke industry, in common with other industries, suffered a relapse. The Frick Company, however, weathered those days of financial shipwreck, and in 1876 H. C. Frick became sole owner of the property of the company. In 1876 there were forty-five plants in the region, with an aggregate of 3578 ovens and a weekly output of 26,000 tons. In 1877 H. C. Frick and his associates leased the Valley plant and other plants near by, and in the same year E. M. Ferguson, who owned a plant of seventy ovens in the region, became associated with the Frick concern under the name of H. C. Frick & Co.

At this time the region underwent a course of railroad development and the firm soon obtained control of most of the plants which had been put in operation there. The partnership continued until 1882, when the firm owned 3000 acres of coking coal lands and operated 1026 ovens. In the meanwhile Mr. Frick had organised the Morewood Coke Company and built the Morewood plant of 470 ovens. The affiliation of the big coke concern with the Carnegie Company dates from January, 1882, when Carnegie Brothers & Co. became members of the firm of H. C. Frick & Co., which latter firm was chartered the following April, with H. C. Frick as its president. It then took the name of the H. C. Frick Coke Company. In the following year the capital was fixed at $3,000,000, and in 1889 it was increased to $5,000,000. The company underwent reorganisation, and an increase of capital to $10,000,000 was made in 1895.

At this time, in view of the fact that the company is the real owner of smaller coke firms operated under various names, it is impossible to state exactly the number of ovens it has in operation in the region, or the acreage of the coal lands owned, but its holdings are sufficient to secure it for some time to come in its position as dictator of the coke market. When reorganised in 1895, it absorbed the 2505 ovens of the McClure Coke Company, its largest competitor in the region. While the absorbed concern was conducted as a distinct coke firm until June 1, 1900, yet it has been reckoned as an integral factor of the Frick firm during the past five years. Since the absorption of the McClure Company a number of other coke firms have become affiliated with the H. C. Frick Coke Company, which owns about 80 per cent. of the 20,462 ovens now in operation in the region. For many years Thomas Lynch, of Scottdale, Pa., has been associated with H. C. Frick in the capacity of manager of his various coke-making enterprises, and the latter is to-day general manager of the company. The colossal proportions which this enterprise has assumed are due to H. C. Frick, and it may be said, as well, that to his organising ability much of the success of the Carnegie Steel Company, Limited, may be attributed. The company has

DRAWING COKE FROM AN OVEN

agencies in all the large cities in the country and does a considerable export business.

While the H. C. Frick Coke Company was branching out in the coke-making business, other capitalists, perceiving the wide field open for profitable investment, secured coal lands in the Connellsville region and erected coking plants. Among the present big operators in the region may be mentioned the W. J. Rainey Company, the Hostetter Coke and Coal Company, the Bessemer Coke Company, the Loyalhannah Coke Company, the Jamison Coal Works, and Saxman & Co. A number of the big iron and steel plants of Pittsburgh are also operating extensive plants in the Connellsville region and thus make their own fuel. The Oliver Iron and Steel Company and the Republic Steel Company have many ovens in operation in Fayette County, and these and other firms are developing the Masontown field of this great coke region.

The Connellsville seam from which this excellent furnace and foundry fuel is produced is a detached portion of the great Pittsburgh coal seam, and it extends along the western slope of the Chestnut Ridge range of the Alleghenies from Latrobe, on the main line of the Pennsylvania Railroad in Westmoreland County, southward across the Pennsylvania State border into Maryland and West Virginia. Its average width is not more than four or five miles, and while the real Connellsville coking coal region does not contain over 100,000 acres, its borders have, in late years, been extended to a much wider limit. However, the fact remains that the true Connellsville coke comes from the original Connellsville region, for the product of those plants which have been put in operation on the borders of the region and at other adjacent points does not come up to the uniform excellence of the real Connellsville coke. But the great demand for this fuel during the past few years and the unprecedented

demand for it just at present give a ready market for all western Pennsylvania and West Virginia coke. As an example of the difficulties experienced in producing a fair article of coke in the ordinary bee-hive ovens from a coal not strictly possessing the qualities of the Connellsville coking coal it may be observed that at Latrobe, the northern end of the coke belt, in Indiana County, Pennsylvania, and at a number of other points, the raw coal must be subjected to a series of washings before it is charged into the ovens, so that the excessive sulphur deposits may be removed. In the Connellsville region no such preliminaries are necessary.

While statistics as to the value of coking coal lands in the region may not be strictly within the province of this article, it may be stated that these lands which, twenty-five or thirty years ago, sold for $15 per acre, are now selling for from $2000 to $3000 per acre, and are difficult to get even at these high figures. In view of the oft-asserted fact that the coking coal lands of this region are fast being depleted, it may be stated that of the 100,000 acres in the region less than one-fifth have been worked out, the remainder, in a large degree, being held by capitalists who operate in the region. In the past lack of system in mining has resulted in large losses of coking coal in the mines worked. With the advances made in mining methods there is now, and will be in the future, greater care practised in mine operation in this region, thus insuring a greater output for the area worked, and there is no immediate danger of a depletion of the supply.

In view of the present agitation for the more economic by-product coking systems, a glance at the processes of operating the bee-hive oven, the type almost exclusively in use in this great coke field, may not be without interest. The ovens are built in single and in double rows, the former being styled "bank" ovens and the latter "block" ovens. The standard bee-hive oven has a diameter of from ten to twelve feet and a height of from six to eight. It is built of firebrick or stone, arched in the interior, with an opening at the top for charging and for the escape of the gases during the coking process. At the lower front side there is an opening for "drawing" the finished product, and this is closed by an iron door during the coking process and while the oven is being charged.

ENGINE AND CARS FOR CHARGING TO OVENS AND LOADING COKE FOR SHIPMENT

The average charge per oven is from

ONE OF THE SHAFTS OF THE H. C. FRICK COKE COMPANY, SHOWING MACHINERY FOR HANDLING COAL

three and one-half to four tons of raw coal. The heavier charge requires more time in the coking process, and the charge when leveled has a depth varying from two and one-half to three feet in the oven, thus leaving sufficient room for the accumulating gases. While it is necessary to ignite the charge when the ovens are first started, this becomes unnecessary after the plant is once in operation. It is the practice to charge every other oven each day and the charge is ignited by the heated walls of the oven. This stage of the process is indicated by a puff, something like the explosion of powder or gas. In twenty-four hours the air holes are all closed, but the gas is allowed to escape through the hole in the top of the oven for several hours longer, depending upon the time to be consumed in the coking process, which time determines the character and quality of the product.

The furnace coke in general use is a forty-eight-hour coke, while the foundry coke requires seventy-two hours in its manufacture. The last twelve hours of the coking process are usually consumed in cooling, and for this cooling it is absolutely necessary that pure water be used. The object in coking is to expel the water, hydro-carbons, and the sulphur and to leave a residuum of fixed carbon, ash, and such of the sulphur as may not be driven off in coking. Should the water used in cooling the coke contain sulphur and other deleterious substances, these would be readily absorbed by the product and would injure the iron manufactured with the coke. With the bee-hive process there are enormous wastes, and while a number of the more economic by-product system plants have been put in operation, the general adoption of these systems in the region is not likely to be carried out for some time.

The coke production for the Connellsville region and adjacent districts in western Pennsylvania for the year 1898 aggregated 10,250,000 tons. It has been estimated that for each ton of coke produced upward of 8000 cubic feet of gas are given off. Allowing that one-half of this is consumed in the coking process, there are still left more than 40,000,000,000 cubic feet, or about two-fifths of the annual natural gas production in the United States during the height of the natural gas excitement.

By going still farther into the wastes of the bee-hive coking system, we find that of the numerous chemical constituents of coking coal the by-product system now in use at various points utilises the illuminating and fuel gas, ammonia, and tar, the latter after passing through the complex processes of modern chemistry being transformed into aniline dyes, saccharine, benzol, and other products. Twenty pounds of sulphate of ammonia are given off from every ton of coal coked, while the yield of tar ranges from 40 to 100 pounds to the ton, depending upon the amount of volatile matter contained in the coal coked. Placing the value of the by-products at the exceedingly low figure of sixty cents to the ton of coke produced, we have a waste from the product of this region for 1898 of upward of $7,000,000 (about £1,400,000), or over one-third of the value of the coke produced in that year. As the product of the Connellsville region for the year 1900 has been estimated to reach 13,000,000 tons, it will be observed that the atmosphere of this region is being blackened by clouds of smoke at an expense of more than $20,000 (£4000) per day for every day in the year.

In the meanwhile, progress toward the introduction of the by-product system has been made. At Dunbar, Pa., in the heart of the region, the Dunbar Furnace Company a few years ago put in operation a plant of fifty ovens of the Semet-Solvay pattern, to which material additions have since been made. This plant was described at length by the writer in an article on "By-product Systems of Coke-Making" published in CASSIER'S MAGAZINE for September, 1897. At Latrobe, Pa., a plant of thirty English bee-hive by-product ovens were put in operation in 1895, and have been operated since at times with but partial success. A large plant of the Otto Hoffman system is in operation at Glassport, on the Monongahela, a few miles above Pittsburgh, not within

the limits of the Connellsville region, and another plant of similar pattern is located at Johnstown, Pa. At Sharon, Pa., a plant of twenty-five Semet-Solvay ovens was established in 1896. The Jones & Laughlins Company, of Pittsburgh, have in operation at their furnaces what might be classed as a retort oven system, but not strictly a by-product one. It may be here observed that the indications are that the by-product oven development, when it takes a firm hold in western Pennsylvania, will evidently be established in close proximity to the mills, foundries, and furnaces of Pittsburgh rather than in the coke region, for this will make possible the utilisation of the gas in the operation of these establishments which, would not be possible were such plants located at a great distance from these establishments. Such an economic advantage would more than offset the cost of transporting the raw coal for operating such coking plants.

It is asserted that the yield from the by-product systems exceeds that from the bee-hive system by 10 per cent., the latter being from 64 per cent. to 68 per cent. of the charge of raw coal. One of the features introduced into the coke business by the H. C. Frick Coke Company is coke crushing, and that firm has now in operation three crushers, with a daily capacity of about 2000 tons. The coke is crushed into sizes to correspond with anthracite coal, and is shipped all over the country for various manufacturing and domestic purposes. This and other firms manufacture a special foundry coke, a seventy-two-hour coke, which combines to the highest degree the requisites of a fuel for exacting foundry purposes.

The development of the coke industry has necessitated the constructing of many miles of railways, and to-day the entire Connellsville region is a perfect network of railway lines. Three great railway systems are competing for the coke-carrying trade of the region, the Pennsylvania Railroad, the Baltimore & Ohio Railroad, and the Pittsburgh & Lake Erie line of the Vanderbilt system. The fact that the branches of all of these systems in the region are among the best paying roads in the United States gives evidence of the great coke carrying trade which to-day amounts to about 200,000 tons weekly.

The present year will witness the greatest era in the history of the region. More new ovens will be built than have been put up in any other year, and the output will probably be increased about 20 per cent. over that of 1898. There are now projected and in course of construction over 4000 ovens. During the last few months the price of coke has more than doubled, and many independent producers have entered the field. On March 1 the employees in the coke region, numbering about 25,000, received an advance of 12½ per cent. in wages, and are now receiving the highest price for their work ever paid in the region. Furnace coke is now selling at $4.50 per ton in Pittsburgh, and bids fair to go far beyond the rate it commanded in the prosperous days of 1879 when it sold for $5 per ton.

Succeeding the development of the Connellsville region the coke industry was established at many other places in the United States, and to-day is manufactured in twenty-three States and Territories. But the Connellsville region still retains its leading position among the coke districts of the world. To-day the product of its flaming ovens is feeding furnaces all over the North American continent, and is known wherever manufacturing has obtained a foothold.

BRITISH AND AMERICAN PATENT SYSTEMS

By G. Croydon Marks, A. M. I. C. E., M. I. M. E.

A COMPARISON between the systems of granting letters patent for inventions in Great Britain and in the United States is alike interesting and instructive, particularly at a period when much discussion is going on concerning the desirability for the amendment of the patent laws of Great Britain.

The progressive increase of business in the United States Patent Office is larger by far than in Great Britain. It is impossible to dismiss such disproportionate development with an explanation that new countries have greater need for new appliances, and that in America precedent and past methods form neither guides nor fetters for those engaged in industrial and manufacturing pursuits. A truer explanation is possibly to be found in the strong belief as to the official proof of validity and consequent freedom from infringement which a patent granted in America is supposed to possess as a result of the search, which is instituted by the American Patent Office before any patent is actually allowed. At the same time it is a fact not to be gainsaid that there is more vexatious interference with inventions by reason of patent litigation in America, notwithstanding such prior official searching, than there is in Great Britain where patents are granted, as in France and Belgium, entirely without search and absolutely in the form in which the applicant applies for them, regardless of the value as to novelty, patentability, or otherwise of the claims set out in such applications.

The applicant for a patent in Great Britain is required to lodge with his application a specification which may be in one of two forms, viz., a provisional or a complete application. The first and most usual form is that in which a "Provisional Specification" is filed containing a description setting out distinctly, yet broadly, the nature and subject-matter of the invention. Too great a particularisation of the details is neither desirable nor necessary in such specification, as it is probable that the main features and essential elements of the invention require some experimental development before the final form and character of the invention can be particularly claimed, set forth, and illustrated. It is in this development of the "Provisional Specification" that one very valuable feature of the British law appears, in that it renders public tests, open experiments, professional, practical, and technical assistance possible to the inventor without risk of piracy or loss of advantage resulting to him during a period of nine months dating from the filing of the application.

Another valuable feature of the provisional period is that which results to the practical man who is desirous of soliciting the aid of a financier, model maker, firm, or friend to assist in the exploitation, testing or working of the invention. Public approach to others for aid can freely be made with the knowledge that such exhibiting of plans, unbosoming of ideas or displaying of results can act in no injurious manner on the patent, whereas any such approach made prior to the obtaining of a provisional protection would be necessarily attendant with risks and undoubted possibilities of loss.

In many large machines or combination devices for producing new and improved results it is a matter of impossibility to bind over to secrecy all who

may happen to be engaged in constructing, testing or using such new invention; hence, it becomes a matter of extreme convenience and security for a provisional patent to be applied for, directly the rough sketches or outline proposals have been produced in a form to be comprehended alike by the patent agent and the patent office examiners. To require that a complete specification, with drawings and claims, should be filed with the application in the first instance would open the door to much vexatious litigation and delay of the form known in America as "interference" cases which arise from alleged priority or simultaneousness of invention.

On or before the expiration of nine months from the date of application the complete specification, accompanied with drawings, where necessary, has to be filed. This must give in detail a clear description of the invention and the method of carrying it into effect, ending with a specific claim or claims for that which is considered to be the novel features discovered by the inventor. The duty of the patent office examiners in studying the specification has reference to ensuring that the two specifications shall agree, that not more than one invention is sought to be patented, and that the description is clear and intelligible. Beyond such no power is vested in them by the present patent laws. The claims may be too wide, or too narrow, or the invention itself may be hopelessly invalid from want of novelty; but these points and defects are allowed to remain at the inventor's own risk. No search of any kind is undertaken, as it is no part of the duty of the patent office to appraise the degrees of novelty or patentability possessed by any application.

Having examined the complete specification for the points required, the patent office issues and advertises a formal acceptance of the specification from which time, for a period of two months, the specification lies open for public inspection and opposition, and printed copies can be purchased by any person. At this stage it is assumed that those inventors likely to be interested in the subject will make themselves familiar with the specification, and, if necessary, oppose the grant, should they find that the inventor seeks to patent that which has been previously patented by them, or that the subject-matter is that which has been obtained from them by fraud or otherwise. Upon such an opposition being placed against the invention, the comptroller, after receiving the necessary documents, hears the applicant and opponent, either personally or through patent agents or counsel, and decides as to refusing the patent or allowing the specification to be amended by a general or specific reference to the specifications which have been cited; the question of actual infringement, however, is not adjudicated upon. From this decision there is an appeal to the Law Officer of the Crown. As showing the extent of the watchfulness of the public over advertised acceptances, about 2000 patents have been thus opposed since 1884, and of this number appeals have been taken to the Law Officer in less than 20 per cent. of the decisions, while only about 2 per cent. of the decisions given by the comptroller have been reversed. If there is no opposition to the patent, or after the final decision in case of opposition, the patent is sealed and issued, the life of a patent being fourteen years, subject to an annuity payable annually after the end of the fourth year.

As against this system of free granting without search to every applicant, irrespective of novelty of actual subject-matter, it is contended by some that many of the payments accepted by the Crown for patents are in the nature of fraudulent receipts, inasmuch as the patent office will grant a patent for the same invention to as many applicants as may care to pay the necessary fees and file the proper specifications, leaving it to the high courts of justice to ultimately decide, if such question ever arises, as to the degree of novelty possessed by each or any of them. On the other hand, inventors of experience declare their preference for the British system, as it is not uncommon to find

specifications which apparently differ but slightly from each other, yet the minute difference is frequently quite sufficient to account for the failure of the one patent and success with the other in commercial use. Such narrowness, if judged by mere paper description, would be held by those not perfectly acquainted with the actual experience connected with the particular art or industry as constituting no subject-matter for invention; and were a patent issued only after an official search, such improvements would be disallowed and the patent grant refused.

In considering this side of the question of narrowness of patent, yet absolute difference of commercial result, it should be remembered that practically every trial of a patent cause establishes this contention, seeing that on a reading of a mere description of words one specification apparently has nothing materially different in principle or method from the one it is alleged to infringe, and it requires careful experiments, models, demonstrations, and expert testimony to demonstrate that the one does not infringe the other. If, then, a learned judge finds it necessary to give several days to the consideration of the testimony ere a judgment can be given concerning conflicting specifications, it can be readily concluded that any power of rejection which might be vested in the patent office as a result of the opinion of the examiner upon prior specifications which are considered to affect the subject-matter of any new application must necessarily be prejudicial to the development and improvement of any industry which happens to have connected with it many patents or descriptions of inventions which have never passed beyond the paper stage, but which would nevertheless be "dogs-in-the-manger," to prevent the granting of new patents having a descriptive resemblance to the older, though unsuccessful, specifications.

That this question of refusal, on official search, to recognise important developments is a fact and not a theory, can be verified by the constant inability of the German and American patent offices to appreciate inventions which have been granted in Great Britain and which have there been commercially successful, and never considered as infringements by those interested in the older patented methods to which the officers have attached undue importance owing to their being necessarily unfamiliar with the technicalities of the industry in its practical workings.

One condition of the grant of the British patent which is most unfortunate in its bearing upon the rights of inventors and their means for obtaining redress for infringement is that of requiring the validity of the entire set of claims contained in the specification. It constantly happens in a patent action that the particular claim infringed is perfectly valid and free from attack, but in consequence of one or more of the subsidiary claims being too broad in terms and thus found to be anticipated by other analogous prior patents, the whole is declared invalid, or the inventor is obliged to apply to the patent office for leave to amend his specification ere he can proceed further with his suit. The proceedings connected with this disclaiming of a portion of the specification are alike tedious and costly, and undoubtedly call for alteration.

The system obtaining in the United States Patent Office differs entirely from that of the British, in that official searching is undertaken, no provisional specification is accepted, no annuities are required, every patent is issued for seventeen years, and, when granted, the particular claim only which is alleged to be infringed is required to be valid when bringing any action under the patent. The weakness or invalidity of any subsidiary claim or claims will not assist a defendant in his attack upon the patent he is alleged to infringe, as each claim is assumed to stand alone, and he must, therefore, confine his attack to the claim which is cited against him.

Every applicant for a patent in America is required to file his application either in the form of a caveat, which is a kind of a provisional protection for securing the rudimentary invention and is open to citizens of America only, or

he must file the application with the specification and drawings complete, similar to the form which would be used in Great Britain for the complete specification. The specification thus deposited is referred to one of the staff of principal examiners, depending upon the subject involved, and the examiner then, by the aid of his staff of assistants, investigates the records and searches all printed specifications and documents connected with the subject-matter, with a view of ascertaining the degree of novelty or patentability of the invention generally, and the relevancy of the claims set forth in the specification. When reporting upon such search the references are given to the inventor of the specifications which are supposed to limit or anticipate his invention, and he is then required to answer such objections as may be thus raised by the patent office.

In the event of the inventions not being considered fully met by the arguments of the applicant or the claims not being sufficiently modified, further report and reference is required. Should the applicant be dissatisfied with the decision of the primary examiner, he can appeal to a board of three principal examiners, and from these can again appeal to the Commissioner of Patents himself, and from this final appeal can also go to the District Court of Columbia on a general appeal against the action and decision of the patent office.

With this safeguarding of the inventor against anticipating specifications, it is assumed by those without experience that the invention thus granted is practically a certified one and free from attack from that which has been done before; but the records of the patent actions in America prove otherwise, as in investigating the merits of the invention the courts of America take no account whatever of the official search which has thus been made, but deal absolutely with the invention from the information and evidence placed before them, upholding or invalidating the patent quite independently of the official decision on the question which the patent office had previously arrived at.

The allowance of the patent office is made known to the inventor, with an intimation that a final definite fee must be paid within six months before the patent can be issued; and after this payment no payment of any kind is required, the patent being granted for seventeen years. The total government tax or fee for this period is $35, or £7, as against £99, the total cost in government fees alone for a British patent of fourteen years.

The amount of business which is done in America in connection with patents points unquestionably to the advantage of a low total fee, although the lapsing of a patent in Great Britain, owing to the failure to pay the annual fee thereon after four years has passed, is a convenient method of getting rid of inventions which, while not being commercially successful, effectually bar the way for improvements upon them while they are in existence. On the other hand, it is possible in some cases, owing to the earlier efforts of the unsuccessful inventor, that others can develop and improve upon his ideas, and it is only right in such cases that his earlier patent should be recognised and some benefit accorded him for what he has initiated. This recognition of early effort is possible with an American patent immediately it is recorded, seeing that it exists for its full life without requiring further attention from the patentee, whereas the British inventor may be indisposed to spend money in maintaining the patent out of which, up to any particular year, he may have received no benefit.

The initial cost in connection with the application for patents is practically less over a given period in Great Britain than in America, seeing that for a fee of £4 the British patent exists for four years, while the American patent never issues at all until a fee of about £7 has been paid. It cannot, therefore, be urged against the British system that the cost of obtaining a patent is less in America than in Great Britain, but the advantage which results to the American patentee is that his patent is considered to be a more marketable security in America than is the British patent in

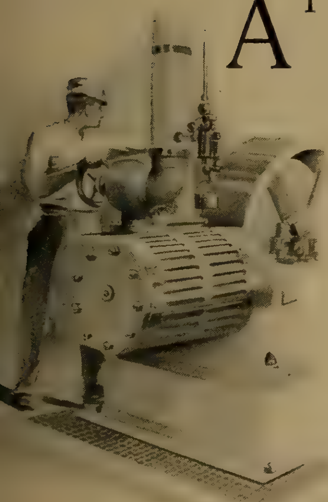
Great Britain, inasmuch as it is more necessary for patents to be fully investigated by the purchaser of a British patent in order that he may ascertain whether there is any shred of validity or title of any kind whatever in that which he contemplates purchasing.

The number of applications filed for patents in America during the past three years have been 130,741, as against 84,388 applied for in Great Britain, while the number of applications actually sealed in America in the same period was 71,588, as against 42,060 patents sealed in Great Britain. The intricacies of the American patent law and the difficulties occasioned in framing claims to meet objections arising from previous patents render the employment of a skillful agent an absolute necessity to the inventor, so that the suggestion which is made in Great Britain in some uninformed quarters that, by the institution of a search, inventors would have no necessity to employ an agent or obtain professional assistance, is found to be against the experience of the American inventor.

MODERN ELECTRIC POWER STATIONS

SOME CONDITIONS GOVERNING THEIR DESIGN

By Phillip Dawson



AT the present time when electric traction is making such rapid strides, the question of the source of supply of power is a very important one. In a paper recently presented before the Tramways' and Light Railways' Association, at London, the author considered this question from the economical point of view in substantially the following manner. This point of view is the most important one, and the engineer's knowledge and experience should be used to design and construct the source of supply of electrical energy in such a manner as to furnish the Board of Trade unit at the switchboard at the lowest possible cost, interest on capital, depreciation and sinking fund included. It may be argued that the cost of the unit at the switchboard being low, it does not necessarily follow that the cost of the power, say, per car or per train mile, will also be low, as it is possible that in order to secure cheap current, the power station may be so located as to cause great expense in feeders, sub-stations and loss in transmission.

In the numerous cases in Great Britain, on the Continent, and in America, which have come under the writer's notice, he has never found this to be the case. This applies to power-supply stations intended for traction and power primarily, and lighting secondarily. It may be mentioned at once that the demand of current for both traction and power-transmission purposes is increasing so rapidly that lighting will shortly in any case be only a secondary consideration.

The combination of a lighting and traction station is not to be recommended, and good results cannot be expected. The case is, however, entirely different where traction and lighting are combined, and the best results are then obtainable, that is to say, where the station has been designed by experienced traction engineers for traction

and lighting. It may be of interest to consider what are the differences between a station designed for lighting and one designed for traction and power transmission.

The average number of hours per annum during which a lighting station will be running full load will probably never be equivalent to more than three months' continuous running per annum, that is to say, taking the total Board of Trade units generated in one year, and seeing how long the plant under consideration would have to run its full capacity continuously to generate this amount, this time would probably never exceed three months. Taking a representative traction station, the time of continuous running would probably be at least nine, and in some cases ten and even eleven months.

A lighting plant must in three months earn enough money to pay working expenses and to pay interest and allow for depreciation and sinking fund for a whole year, whereas a traction plant has from nine to eleven months to do the same thing.

A lighting plant is, on an average, practically at a standstill eighteen hours a day, while a traction plant is running eighteen to twenty hours a day. Economical boilers, engines, and electrical generating and transmission devices are, therefore, far more important in a traction than in a lighting plant, because it is well known that running at very light loads and keeping the fires banked and the boilers, steam pipes, and engines hot, uses very nearly as much fuel as running them at full load.

Furthermore, whereas in a lighting plant there is ample time to overhaul the plant and execute necessary repairs, the men during the day have little or nothing to do, and can well do this work. In a traction plant there is little or no time to do this. The conditions are quite, if not more, arduous than on a ship. There at least every few days or few weeks the whole plant is entirely shut down for several days and can be taken to pieces and overhauled.

Unexpected and rapid overloads must be able to be supported by the traction plant, which is not generally the case in lighting.

In a traction station it will be seen that a far greater figure is cut by the cost of generation, pure and simple, than in a lighting station, and that the question of interest on capital expenditure and sinking fund is relatively smaller in the former than in the latter.

The following figures, which are the result of actual experience, may be of interest, and show the influence of continuous running on the cost of production:—

Cost in Pence Per Board of Trade Unit.

	Lighting.	Traction.
Fuel	0.03 to 2.2 d.	0.09 to 0.5 d.
Oil, waste and stores	0.05 " 0.38d.	0.005 " 0.2 d.
Wages and salaries	0.26 " 1.60d.	0.03 " 0.4 d.
Maintenance	0.054 " 0.6 d.	0.0025 " 0.06d.
Total	0.684 " 4.78d.	0.1275 " 1.16d.

The difference which exists between a plant working practically continuously and only intermittently is at once seen in the average amount of coal consumed per unit generated. The type of engine used must, however, also be taken into consideration.

Thus, taking the published results of British electric light plants, we find that the cost of coal per unit generated varies approximately between 0.3d. and 2.2d. Comparing this to traction plants, we find the cost of coal varying between 0.09d. and 0.50d. per unit generated. Again, considering the item of wages and salaries in a lighting station, we have 0.3d to 1.6d.; in the case of traction this is 0.03d. to 0.40d. per unit.

Comparing the total cost of production of one Board of Trade unit generated in a lighting station and one in a traction station, interest and sinking fund excluded, in the former the unit varies from 1.00d. to 4.00d., as compared with 0.25d. to 1.00d. for traction purposes. The cost of power when generated for traction and power purposes is one-quarter of that generated for lighting only.

The amount to be added for interest and sinking fund, of course, depends on the length of the concession, on the terms of final purchase, and on the life of the machinery employed. The cost of producing power varies with the

amount to be produced, decreasing as the amount increases. This shows the advisability of concentrating as much power as possible in one station, and reducing the number of units.

In considering the various items which go to make a complete power or traction installation, including the system of feeders, distributers, track, and overhead line, the cost of the power station is but a comparatively small item. The saving which can be effected by a properly designed station is very great, and a little extra capital expenditure is in many cases well justified.

The total cost of running an electric tramway or railway varies between 2.50d. and 8.00d. per car mile, according to circumstances, the electrical energy at the power station required varying from 0.49 unit to 1.4 units per car mile, according to the profile of the line and the weight and speed of the cars.

The cost of power varies between 10 and 30 per cent. of the total working expenses, all charges included, and if it can be reduced by ¾d. to 1d. per unit, or we may say per car mile, as one unit at the switchboard is a fair estimate of the average power requisite at the switchboard per car mile run, is well worth doing.

In the early days, before polyphase high-tension currents were known, the situation of the central station was practically imposed, very little latitude being possible owing to the maximum distance of economical transmission being limited. Electricity works being most required in crowded centres, it was not only difficult to obtain a site at all, but the cost of the ground was very great. Hence the necessity of crowding the greatest amount of power into the smallest possible space. The plant being mostly used for lighting and running only a few hours each day, highly economical engines and boilers and labour-saving appliances were of but little advantage. At present circumstances have altered; electricity can be economically transmitted to any distance, and is utilised,—and will be more and more so every day,—firstly for power purposes, and secondly for lighting purposes.

The initial cost of a plant may be roughly divided into four parts,—land and buildings; plant, including all machinery in station; mains, feeders and distributers; miscellaneous, which includes such things as meters, instruments, cost of provisional order, and such like.

According to Mr. Emile Garcke's figures in the "Manual of Electrical Undertakings," the average cost of existing British plants expressed in percentage of total capital expenditure is approximately as follows:—

Land and buildings	19 to 23 per cent.
Machinery and plant	36 to 37 per cent.
Various remaining items	4 to 14 per cent.

As regards the first item, the above average includes several old lighting stations, and there is little doubt that if a new plant were installed the cost of land would be materially reduced.

The question of system of generation, whether in several large stations, generating continuous current, or in one large station, generating either continuous or polyphase currents, is of great moment.

As has been stated previously, in a traction station much greater capital expenditure is justified, and coal-handling appliances can be installed which enable one or two men to look after the largest boiler room. Automatic lubricating systems, ash conveyors, etc., make one or two men quite sufficient in the largest engine room. It will be evident that the item wages and salaries will be far greater in several than in one station. Also the waste of coal, etc., will be far greater. From a careful study it is nearly certain that, for anything above 5000-kilowatt capacity, one polyphase station operating rotary-converter sub stations is the best. Large units are also always advisable. It is interesting to the writer to see that the sizes of units recommended by him several years ago are generally being adopted. For reference, it may, perhaps, be interesting to refer to the table on the next page

All engine builders who have had experience in tramway work now make an

entirely different kind of engine for traction from that which they supply for lighting stations. The conditions under which a tramway engine works are, if anything, more onerous than those of a rolling-mill engine. A slight variation, either in number of revolutions per minute, or in angular velocity per revolution, is of the greatest importance in a traction station, whereas it is of small importance in a rolling mill.

SIZES OF ENGINES RCCOMMENDED FOR USE IN POWER STATIONS.

Maximum Power Required, I. H. P.	Number of Engines.	Power of Each Engine, I. H. P.
200	2	200
400	3	200
600	3	300
1,000	3	500
1,500	4	500
2,000	4	750
5,000	6	1,000
10,000	6	2,000
20,000	6	4,000
40,000	9	5,000
60,000	11	6,000
90,000	10	10,000

A uniform speed is especially important where compound-wound dynamos are run in parallel direct on to the line. If the momentary difference in speed between two engines exceeds very narrow limits, the voltages of the machines differ, and cause very heavy currents in the equalising bars, and largely increased core losses, hence great waste. If the difference becomes too great, one of the generators may even be reversed. Where multiphase machines run in parallel, constant speed is of even greater importance to keep the machines in step. In cases where shunt-wound generators with heavy batteries of accumulators run in parallel on the line, the question of engine regulation is not so important.

A traction station where compound-wound dynamos are used should be so arranged that, if the normal load be suddenly thrown on or off an engine, the speed shall not vary more than 2 per cent. either way. In some cases a maximum variation of 1½ and 1¾ per cent. is all that is allowed. When polyphase currents are used, constant speed is of even greater importance; and a guarantee should be required that under no circumstances shall the angular velocity during one revolution vary more than one-half per cent. With heavy fly-wheels, and governors properly designed for tramway work, it is quite practicable to fulfil the above conditions.

From careful comparison of many existing systems, it may be taken that the total cost of power, all fixed charges included, for one large station, as compared with that for two or more smaller stations, together equal in power to the larger one, is from 30 to 75 per cent. lower.

ONE OF THE ELECTRIC TUGBOATS ON THE CHARLEROI CANAL

ELECTRIC HAULAGE IN BELGIUM

ON THE CHARLEROI CANAL

By Léon Gérard.

PROBABLY the most interesting example now in existence of electric haulage on canals is found in Belgium, on the Charleroi Canal, at Brussels. The canal is a very narrow one, about 50 miles long, and connects the Charleroi coal district with the port of Anvers, passing Brussels on the way. The important Mons district is not yet connected with the sea, except through French territory, and the Liège district reaches Anvers through about 120 miles of canal and river. This explains why British and German coal compares very favourably in price with Belgian coal, even at Brussels, which is 31 miles distant from Anvers by canal route.

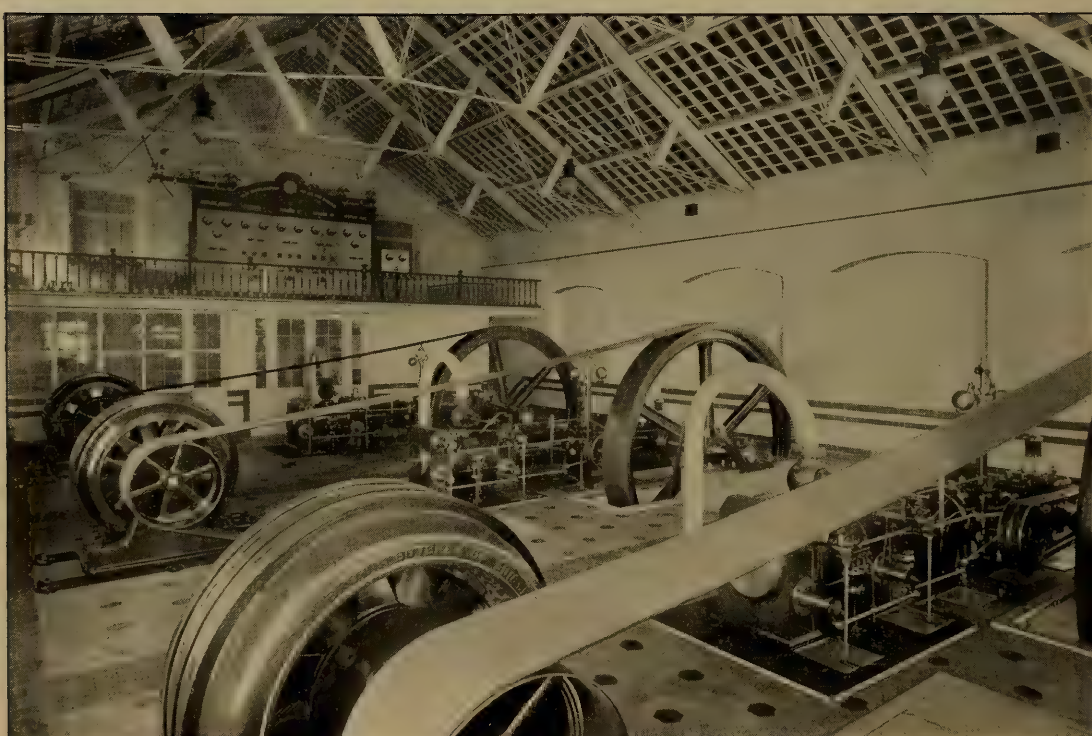
It was, therefore, of great commercial importance to connect Brussels by waterway in a more efficient manner with the coal basin of Charleroi, and this was done by electric towing of the boats on the canal. With the old way of towing the boats by horses a speed of 1¼ miles an hour was obtained, but with the electric system this has been increased to from 2½ to 3 miles, with no more expense per mile for the same tonnage. The cost is about two shillings per boat per mile. The boats have a capacity of 70 tons, and the annual traffic amounts to about 600,000 tons.

The haulage system on the canal has been laid out according to the designs and under the direction of the writer, and comprises a number of small electric road carriages,—automobiles they might be termed,—rated at about 5 H. P., which take the places of the horses previously used. Electric current for the three-phase motors is taken from overhead conductors through three separate trolleys, as shown in the illustration on page 217. There are altogether eight overhead wires, the lowest three being the trolley wires which supply current at 600 volts; the upper three are feeder wires carrying current at 6000

MOTOR CARRIAGES ON THE CHARLEROI CANAL

ANOTHER VIEW, SHOWING WINCH AT REAR

THE POWER STATION AT OISQUERCQ



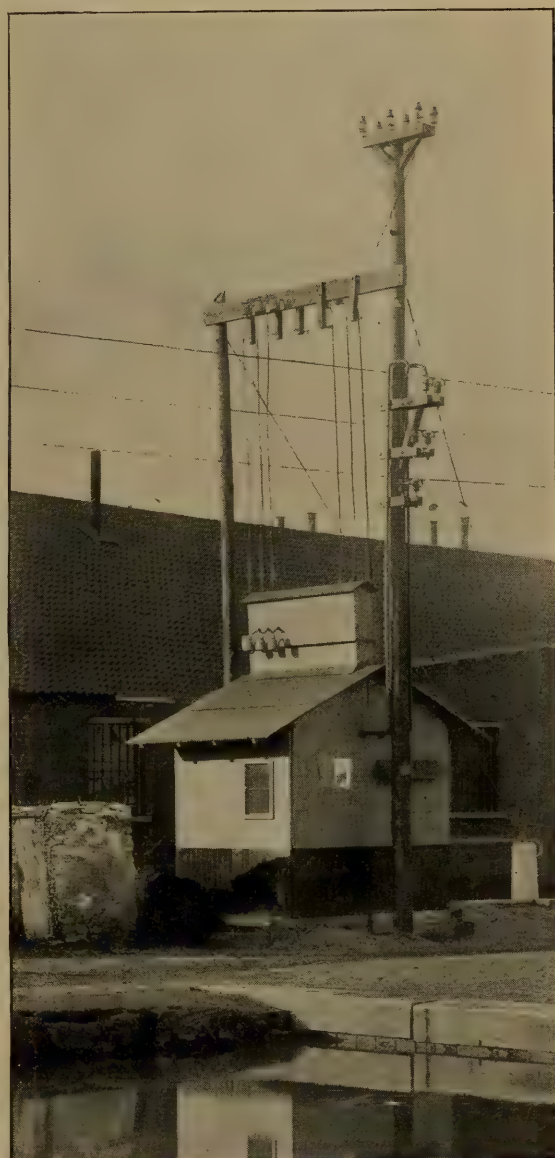
A VIEW OF THE INTERIOR

volts; and the two intermediate wires on the small insulators are for telephone service between all the sub-stations along the line and the main power stations. The sub-stations are three miles apart, and each contains a transformer outfit for bringing the voltage down to the 600-mark for the trolley lines.

The whole 50-mile course between Brussels and Charleroi is supplied from two generating stations, one at Oisquercq, 15 miles south of Brussels, and the other at Roux, 6 miles north of Charleroi, the two being 29 miles apart. The Oisquercq station contains three 125 H. P. Corliss engines, driving three Brown-Boveri three-phase alternators at 6000 volts and 10 ampères. The arrangement at the Roux station is similar, but the engines there are of 325 H. P. each. As that particular part of Belgium is the most thickly populated and also the most active in an industrial way, it is not astonishing that the electric power available from these stations should be applied to other uses besides towing on the canal, and we find, therefore, that it serves for lighting purposes in many places, and for driving various small establishments, operating printing presses, looms, forge bellows, woodworking and other machinery. Indeed, the rapidly growing demand for current for these secondary uses, as they might be considered, was what prompted the laying out of the station at Roux on a larger scale.

The canal automobiles work over sections of varying length. A motor tows its boat until it meets another one going in the opposite direction. The two do not pass each other, but exchange tow-lines and retrace their routes. The driver has two seats at his disposal, one for each direction; consequently the motors have neither to turn nor to exchange trolleys. The exchanging of the tow-lines occupies about a minute.

The banks of the canal are so narrow that passing of two motors would be dangerous; in fact, on certain parts of the canal the banks are in such poor shape that, instead of using the motor carriages mentioned, electrically-driven tugboats have to be employed. One of these is shown in the illustration at the head of this article. The current for these boats is taken off through a trolley of the kind shown on page 221. A speed of between seven and eight miles an hour can be maintained without throwing the trolley off the line.

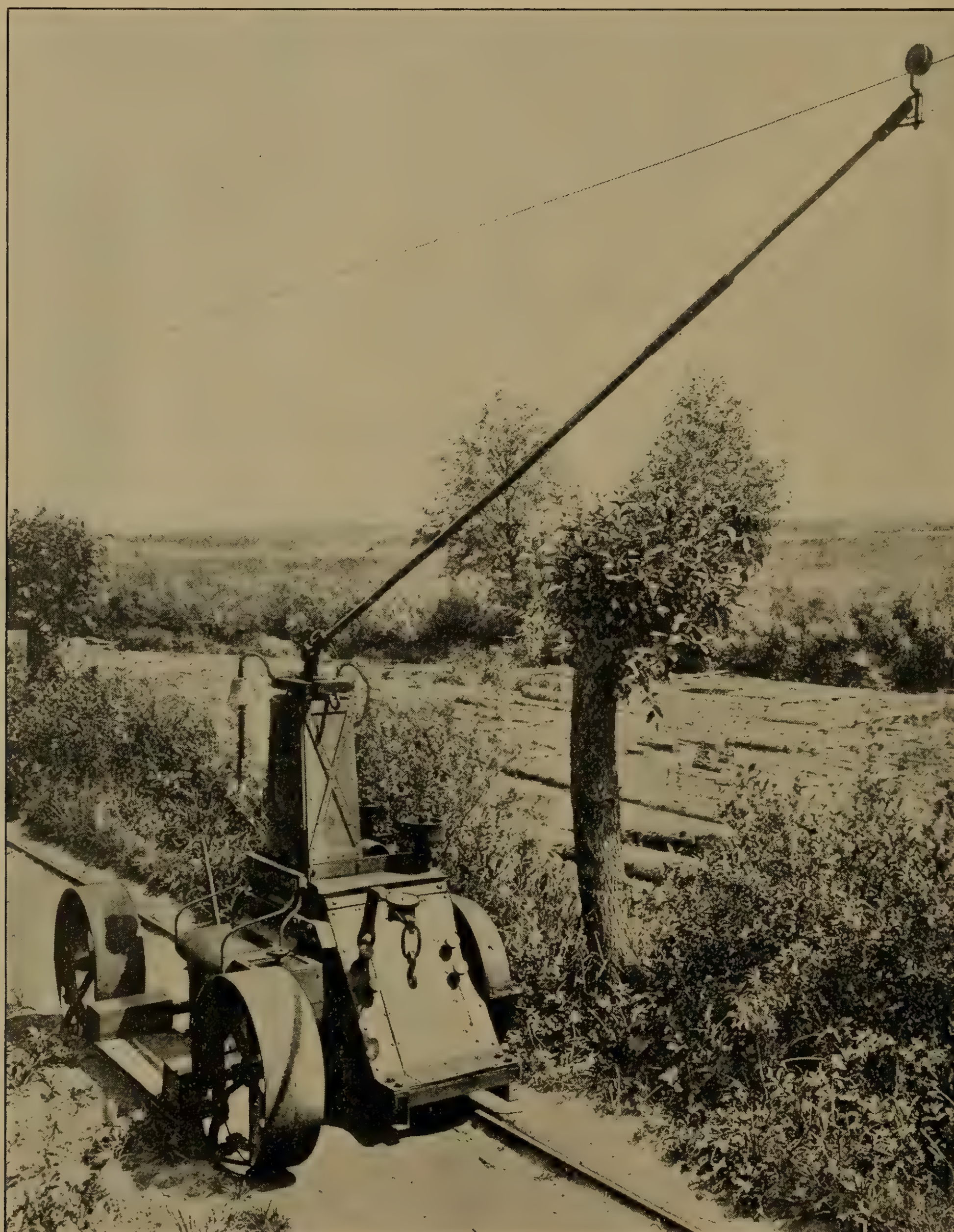


ONE OF THE SUB-STATIONS

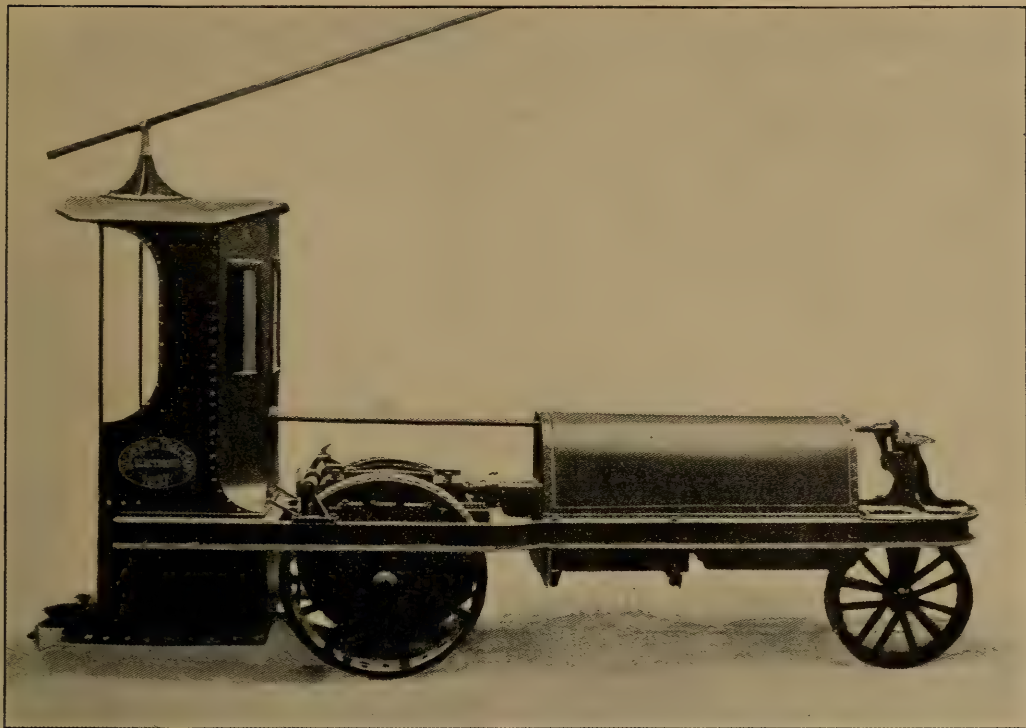
The current is conveyed to the boat through an insulated cable of three conductors, supported by the boom on the vessel's mast. In towing two 70-ton boats a speed of about two miles an hour is reached. The system of the boom, of the cable and the trolley is so perfect that the tug is entirely free to turn round like a steamboat; it can keep

at a distance of 60 feet from the line, though its mast is only 14 feet above the water. With large tugs and a suitable mast the distance from the tug to the line could be increased up to 90 feet.

In the illustration on page 217 the operator is shown with his left hand on the controller and his right on the steering gear; further to the right he has the handle of the brake necessary for holding the car on the inclines at the locks. The passage of a lock is greatly facilitated by the use of the traction motors. It is in these passages that the towing horses used formerly to suffer most On the Charleroi Canal the passage of a lock with horses required about fifteen minutes; now the work is done in four minutes, and sometimes in three. Where great tractive power is required, —for example, to relieve a stranded boat, or to force a boat out of a lock, —the motor car carries a winch at the rear. This can be coupled on to the motor axle which the driver disconnects from the wheels, locking these by the brake. A system of electric canal-boat



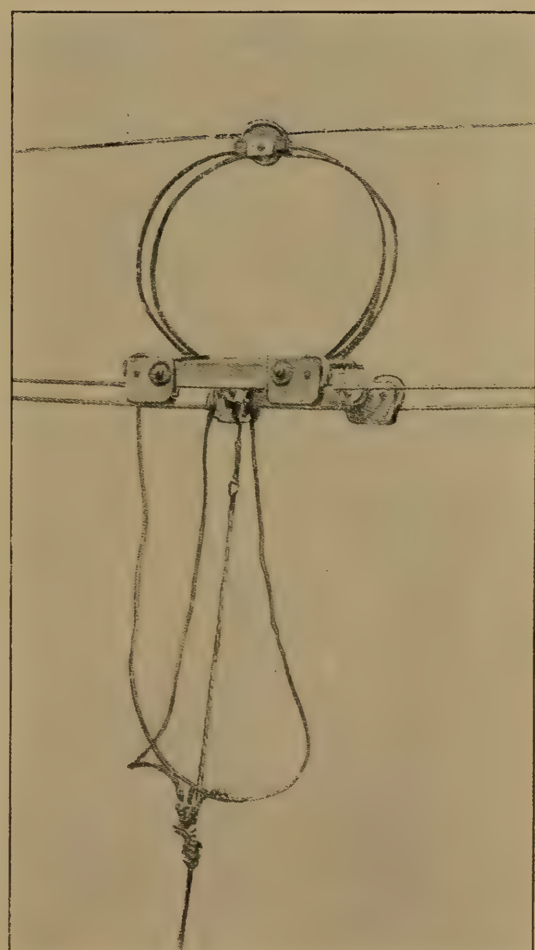
A SINGLE-RAIL CANAL MOTOR ON THE FINOW CANAL, GERMANY



A FRENCH CANAL AUTOMOBILE

haulage is also operated successfully in France. It is due to M. Léon Gaillot, Engineer of Bridges and Roads at Dijon, and to M. La Rivière, Government Chief Engineer at Lille, who has done much to further its development in France. The French apparatus is a tricycle, shown on this page, operated by worm gearing. The speed of the motor is 1½ to 2 miles per hour. The barges are boats of 250 to 300 tons on the canal of Aire and Deule, between Douai and Béthune. The French Government has laid down good gravel paths on each side of this canal, the cars going up taking the left bank and those going down, the right bank, and in this respect the system is superior to the Belgian single-path installation. The French plant uses continuous current at 500 volts from stations five or six miles apart.

In Germany electric canal haulage has not made much practical progress. In connection with the firm of Siemens & Halske, of Berlin, the German Government has, however, made some interesting experiments on the Finow Canal at Eberswald. A 900-yard trial section was constructed there, and experiments were made with several differ-



THE THREE-PHASE CHARLEROI CANAL TUGBOAT TROLLEY

ent systems, the latest being represented, in part, on page 220. Continuous current is employed with an overhead trolley arrangement. The motor might be described as a single-rail locomotive, its general features being shown very well in the illustration. The advantage is claimed for the system that the motor can be operated without a special attendant, being guided along the canal bank by the single rail. Nothing has yet been done with the system in a practical way, but the attention which it has received is an additional illustration of the rapidly growing importance of electric traction on canals and the likelihood of its extensive development in the near future.

LIGHTING BY ACETYLENE

SOME POINTS ON GENERATING AND USING THE GAS

By Theodore Varney

ACETYLENE, and calcium carbide, from which it is obtained, have been before the public as commercial possibilities for about five or six years. During this time it has had to meet the opposition of conservatism and conflicting interests, as is ever the case with innovations. From a careful examination of the conditions, it would seem that the very simplicity of the method of generating the gas, which, at first sight, is its greatest recommendation, has been, in a large degree, the means of retarding its wider introduction.

To the unscientific person of inventive inclinations, the acetylene gas generator has been an inviting field of operation. The result has been that many crude devices have been offered for sale and frequently advertised with greater skill than was manifest in the construction of the apparatus itself. In their eagerness these makers have invariably asserted the perfection of their machines, and where accidents have occurred or defects have developed, it has been difficult to separate facts from the many conflicting reports. The true cause of many accidents has thus been overlooked or ascribed to carelessness of the operator, when, in fact, the difficulty was traceable to defective design or construction of apparatus.

The first requisite in designing acetylene apparatus should naturally be a thorough understanding of the principles underlying the action of water upon calcium carbide in its various commercial forms. Calcium carbide is a hard, stone-like substance, formed by the action of the intense heat of the electric arc upon a finely powdered and intimate mixture of lime and coke. The carbide is broken up in crushers, and is usually found on the market in 100-pound cans covered with wood lagging. The average size of lump carbide varies from about a 2-inch cube to pieces of two or three pounds' weight, while grades known as "¾" and "¼" inch are also to be had. The last two sizes are obtained by screening.

The carbide, when brought in contact with water, liberates acetylene gas, while ordinary lime is left as residuum. Each pound of carbide requires but about half a pint of water to complete the chemical reaction and liberate all of the gas, but as each pound of carbide, in slaking, gives off enough heat to raise one gallon of water nearly 90 degrees Fahr., the residuum would be raised to a dangerously high temperature. The only safe way is to apply sufficient water to flood the residuum, the amount necessary varying in different types of generators.

This heating effect is nearly always either entirely overlooked or only par-

tially overcome by the average generator maker. When his attention is directed to evidences of heat in the generator he invariably asks, "Well, what of it?" The answer is simple. Acetylene ignites in air at about 896 degrees Fahr., and in cases where a relatively small amount of water is applied to the carbide this temperature may readily be obtained. Several cases have come under the writer's observation where the carbide receptacle presented a glowing mass when removed from the generator, and burst into flame when in contact with the air.

There is, fortunately, a simple means of determining whether a dangerous temperature has been reached, and that is by the appearance of the residuum. When properly slaked, this has the appearance of ordinary lime, and is of a pearly gray colour; but if it has been overheated, traces of brown will appear, due to the presence of coal tar products caused by the overheating of the acetylene. These brown impurities appear at about 536 degrees Fahr., and, aside from the danger of ignition in the generator, they reduce the candle power of the gas, clog the burners, and tend to form explosive compounds with the copper in brass fixtures. Therefore, it may be said to the prospective purchaser of acetylene apparatus, buy none in which the residuum, when removed, is brown in colour.

The next property requiring careful consideration is the explosiveness of the gas. Much has been written of the dangerous character of the gas itself, even without mixture with air; but it has been pretty definitely determined that the pure gas, when properly generated, and maintained at low pressures, will not explode from shock or fire. When compressed to two atmospheres it begins to show explosive qualities when heated. When, however, air is mixed with acetylene, it becomes violently explosive, the range of explosiveness extending from about 3.1 per cent. of gas to 24 per cent., some authorities placing the upper limit as high as 82 per cent. In the form of burner usually employed the openings in the lava tips are very small, and a match may be applied to such a burner, passing a mixture of gas and air, without danger of explosion; but such is not the case if the burner tip be removed from the fixture. Bearing these facts in mind, the generator must be constructed to contain a minimum of dead air space when first started. The lesson of experience has been that the person starting the apparatus frequently becomes impatient in waiting for the small blue flames to reach their full size and brilliancy, and he removes the burner tips to accelerate matters, trying the openings with a match. This method, while invariably effective in determining whether or not the air mixture has passed off, cannot be employed with safety to the person or surrounding property. Many such instances are on record, and have, correctly enough, been set down to carelessness, but the primary cause of the difficulty is defective design of the apparatus. It is entirely possible to construct apparatus which will give almost pure gas immediately. Further than this, the portion of the machine which must be opened for recharging should not introduce a large amount of air into the system.

To these conditions and to one other practically all accidents thus far recorded may be attributed, although the causes producing these conditions were numerous. It is repeatedly stated by generator men that acetylene, being of slightly less density than air, rapidly diffuses, and that it would require a large amount of escaping gas to produce explosive mixtures in a room. Cases are on record, however, where by draughts a current of escaping gas has been carried many yards, and, igniting at distant fires, has flashed back to the machine, doing much damage. Another provision thus becomes imperative. The apparatus must be provided with a safety pipe of ample size leading outdoors and extending at least 12 feet above ground. The open end of the pipe should be well protected by wire netting or other means against stoppage by wasps' or birds' nests, and should have a return bend to keep out rain

water. Much depends upon the efficiency of this safety pipe.

Still another feature is essential to the safety of the apparatus, but under pressure of competition it is frequently neglected. With a view to increasing profits, makers of machines are frequently induced to rate them above their real capacity; that is, provision is not made for the quantity of carbide necessary to supply the specified number of lights. The charge becoming exhausted, the lights go out, necessitating recharging at night. This is a dangerous operation by artificial light, and should be avoided. In purchasing a machine, the buyer should see that an allowance is made in the generator for at least eight-tenths of a pound of carbide for every half-foot burner. For a dwelling this allowance would probably suffice for the daily lighting period; but for other conditions of service, the amount should be increased accordingly.

A type of machine which has recently received considerable attention consists of a form of carbide hopper having a sloping or conical bottom, and fitted with a feeding mechanism arranged to admit carbide to a water tank below in proportion to the demand of the lights. This type is known as the "carbide feed" machine, and is intended for the use of ¼-inch or fine carbide without large lumps. This type presents the advantages of small size and compactness for large capacity, no after-generation or waste of gas when lights are extinguished, and ability to carry heavy overloads. On the other hand, the fine carbide contains slightly less gas per pound than lump carbide (about 4½ cubic feet per pound), and great care must be exercised in the construction of the feed mechanism to prevent clogging and possibility of excessive and sudden discharge of carbide into the water. Fine carbide, on striking the water, is converted into gas almost instantly, and care must be exercised to prevent development of dangerous pressures. It may be said that this type of machine presents great possibilities in the field of automatic generators.

The manufacturer having made ample provision for all these matters, it further remains for him to provide for a steady and uniform pressure in the apparatus, to provide automatic means for removing all condensation in the piping, and to pay strict attention to simplicity and substantial construction. If it may be assumed that the purchaser has obtained such a machine, it remains for him to place it in charge of a competent person who will not neglect it at the proper time for cleaning and recharging, and will under no circumstances bring an open light near it.

At present it does not appear likely that acetylene will become a serious competitor of electric light or city gas in the larger towns, but in small towns and villages where the amount of lighting done will not warrant the expenditure called for by electric or city gas plants, acetylene is eminently well adapted. For isolated buildings of various kinds it is an ideal illuminant. If the user of an acetylene gas machine will but bear in mind the fact that he is operating his own gas works and will act accordingly, there is no reason why acetylene should not prove a reliable and satisfactory form of illuminant.

Little has been said in the above regarding the use of acetylene under high pressure. While this subject has been experimented upon to some extent, it has not yet been sufficiently investigated to make known, and enable provision for, the exact conditions necessary to prevent explosion. As it is, many serious accidents have occurred from the use of the gas under such pressure.

ELECTRIC FIRE RISKS

By Hubert S. Wynkoop

IN accordance with that law of compensation under which nature imposes upon us greater responsibilities in return for greater comforts, the employment of electricity for such domestic purposes as heating and lighting gives rise to more numerous chances of danger than accompany the use of gas or oil. This is not to be interpreted to mean that of the agents,—whether oil, gas, or electricity,—one is more dangerous intrinsically than another, but, rather, that popular unfamiliarity with the latest illuminant leads to a careless handling of electric appliances.

Everyone knows that the filling or the overturning of a lighted oil lamp may start a fire, sometimes preceded by an explosion; similarly, it is a matter of common information that the blowing out of a gas jet conduces to asphyxiation, and that searching for a gas leak with a lighted candle invites an explosion. Therefore, most people refrain from experimenting along these lines, though they may be guilty of outrageous practices in connection with electricity. Comparatively few of the great body of the public are familiar with even the simplest laws of electrical cause and effect; the knowledge of the many is limited to an ability to turn on or off an electric light by means of a key or switch, or to replace a burnt-out lamp with a new one. Evidences of the general ignorance on this subject are everywhere apparent,—nails and screws driven into electric light moulding, wires in contact with foreign metallic objects, fuses uncovered so that molten metal may fly about among easily ignitible material, and conductors so overloaded as to be perceptibly hot.

Some of these evils are due to faulty installation; others, to careless or ignorant handling during service. In the former case, ignorant or unscrupulous persons impose upon the householder, so that his wiring becomes a memorial to the contractor's dishonesty or incompetency; in the latter, the blame rests solely upon the householder himself.

That the situation is not worse is due primarily to the fire underwriters, who at an early date in electric lighting history realised the importance of restricting indiscriminate methods of construction, in order that the greatest possible immunity from fires might be secured. In the United States the present rules of the National Board of Fire Underwriters are the standard for electrical construction throughout the country, and work carried out strictly in accordance with their requirements is safe when subjected to reasonable care in subsequent handling. These rules have been developed during the past twenty years, and are still in process of evolution.

The electrical inspection performed by the underwriters, intelligent, honest, and painstaking though it be, is not in all respects satisfactory. It rests upon no provision of law, so that, if the construction prove faulty, the insurance companies have no way of compelling the removal of the menace other than by the purely moral methods of increasing the premium or suspending the policy until alterations shall have been made. The inspector concerning himself with fire risks on policy-covered property only, has no power, however, and but little inclination, to trespass

upon uninsured premises for purposes of investigation. A fee is usually charged for inspection, and this burden, falling upon the insured, largely augments the premium in the case of a small policy, and in any event encourages concealment of electric alterations or additions, because each notification which results in an inspection entails an additional expense upon the tenant. Furthermore, since the object of the underwriter's inspection is to secure reduced insurance risks, it follows logically that higher premiums permit of taking greater chances, and, consequently, different standards of construction are applied to different householders, according to the rates paid by them.

Several American cities have already instituted systematised electrical inspections and are obtaining satisfactory results from them. Indeed, Chicago has progressed so far that the underwriters themselves, it is stated, have for the past five or six years accepted the city certificates, making few or no inspections themselves; but Chicago is particularly fortunate in the possession of ample and explicit ordinances governing electrical appliances and providing penalties for violation of the rules. Custom differs in various localities as to the charging of fees for inspections; but whichever system be preferred, there can be hardly any doubt that a rigid electrical inspection should be undertaken, under due authority of law, in every community large enough to boast of a sanitary inspector or a fire marshal,—if there be in the community any buildings lighted by electricity or served with electric power.

The argument has been frequently advanced that, inasmuch as the underwriters have more at stake than the city authorities, the former should be more worthy of confidence than the latter, and that the most good for the least money may be attained by legalising the work of the insurance companies. The custom prevailing in a number of localities which requires independent inspections by the city, by the fire underwriters, and, frequently, by the operating companies as well, involves not only a waste of official energy, but unnecessary annoyance and delay to the occupant of the premises. It seems to the writer that the municipal inspection alone should be required before the appliances are placed in service. A more leisurely investigation of new work, with a view to checking the accuracy of the city inspections, and a periodic survey of old work,—for which a large city finds but little opportunity,—would then become the proper functions of the electrical bureaus of the underwriters.

While the operation of electrical appliances in buildings is fraught with many dangers if the installation be faulty or the maintenance in unintelligent hands, there is no reason why one should hesitate to avail himself of this modern agent of light, heat, and power. The standard rules governing this subject represent the experience gained through a systematic investigation of fires attributable to electric origin. Unfortunately, there are persons engaged in the wiring business who, either through wilful neglect or through ignorance, depart from the requirements laid down by experience, and it is physically impossible for any inspection department to watch work so carefully as to absolutely prevent the existence of defects. In the city of New York, for example, there are twelve or fifteen hundred electrical contractors, each of whom employs from one to fifty men; and, unless an inspector could be assigned permanently to each of these men, there would remain the possibility of some defects being overlooked. However, the moral effect of the inspection system tends to guarantee the excellence of material and workmanship, for the workman cannot predict what portion of the installation will receive the closest scrutiny, and he is, therefore, not likely to slur any portion of it.

While the last statement holds true generally, there are some exceptions, arising from two reasons. One is the complexity of the rules which makes some portions of them not easily understood, and which can be removed only

by rearrangement. The other reason is a desire on the part of the contractor to undertake the cheapest construction permissible and a tendency to omit those details whose absence is likely to escape detection. To eliminate this evil, provision should be made for the imposition of a penalty to cover intentional neglect of the official requirements or failure to remedy defects within a reasonable time after the service of an appropriate notice upon the negligent person.

The passage of suitable laws providing for the licensing of electrical workers would prove an efficient deterrent to poor work. The plumbing trade is subject to such legal control, and the results attained are eminently satisfactory. A master plumber who knows that his license and his bond are at stake is greatly concerned as to the conscientiousness and ability displayed by his subordinates; and there appears to be no good reason for exempting electrical workmen from similar control.

Aside from the shock attendant upon the passage of electricity through the human body,—a contingency rather remote, and one resulting always from abnormal conditions or careless handling,—the overheating of ignitible material is the one electrical danger to be apprehended. With electricity such heating may result from various causes. The amount of heat generated by the transmission of electrical energy depends, in general terms, upon the resistance encountered in the conducting medium, the quantity of current flowing, and the rapidity of heat radiation. For this reason a poorly constructed joint in wire laid in wooden moulding may, by interposing a high resistance, develop a local heat sufficient to char the woodwork, which eventually bursts into flame; or, a circuit designed for the supply of sixteen candle power lamps, may be called upon to carry the same number of lamps of thirty-two candle power, thus doubling the flow of current and causing an increased heating effect throughout the entire length of wire; or, a wire designed for carrying a certain current when strung on insulators and exposed to the air, may be placed in wooden moulding, at the whim of the tenant, who cannot understand why a larger wire is required for the latter method because he does not stop to consider the decrease in the rate of heat radiation which results from the change. So, also, the presence of weak or defective insulation may cause a series of infinitesimal leaks from wire to wire, which, added together, assume finite proportions, and may result in adding to a circuit a burden entirely ignored in calculations of wire sizes.

To guard against this overheating the insertion of a " fuse " in the line is usually resorted to. This is a strip of metal of such material and cross-section as to insure its melting,—and thus opening the circuit,—upon the passage of a current sufficient to barely overheat the wire. The fuse, however, is no protection against the heat developed at bad joints or at points where leakage from one wire to another (or to some other conducting medium) is localised. It prevents an excessive flow merely, not a flow along unauthorised paths or over improper obstructions. And yet heavy copper or iron wire is not infrequently used to replace these fuses, thus defeating the object of the device; and, indeed, cases are on record where the brass-capped fuse plugs were filled solid with lead, in order, as the engineer expressed it, " to do away with the only weak part of the system! "

When a fuse " blows," it invariably scatters molten metal, which may communicate a dangerous degree of heat to the material upon which it falls; and yet very many people fail to understand why the inspector requires that the fusing appliance shall be enclosed in a non-combustible case.

The only protection against poor joints lies in the prevention of them. The best protection against local leakage consists in the adoption of a good insulating covering for the wires and of such a method of construction as would permit of the operation of the circuits without leakage if the wires were entirely uncovered, in which case the insulation becomes an efficient factor of safety. The first general suggestion

which appears in the rules of the National Board of Fire Underwriters of the United States reads as follows:—

"In all electric work, conductors, however well insulated, should always be treated as bare, to the end that under no conditions existing, or likely to exist, can a grounding or short circuit occur, and so that all leakage from conductor to conductor, or between conductor and ground, may be reduced to a minimum."

"Grounding" is the development of a possible path from one wire to some foreign conducting medium, as, for example, a gas pipe or a metal ceiling; a "short circuit" is a path from one wire to another. Upon this fundamental suggestion by far the greater part of the rules of the above board are based.

An acquaintance of the writer, practised in the designing of appliances electrical, is fond of characterising each invention as it comes out as "fool-proof"; and the dominant thought which guides his labours is to so construct his devices that the misuse of them entails more labour than does their proper operation. So it is with the electric wiring rules; they are intended to render the whole construction "fool-proof." Many a provision in them which seems altogether useless at first blush, has been inserted with a view to guarding against the repetition of accidents which have actually happened; and, if we accept the general intent of the rules, we must perforce agree to observe their detailed requirements.

FOUNDATIONS ON A WATERLOGGED SUBSOIL

By C. S. Vesey Brown, Assoc. Mem. Inst. C. E.

THE Lincoln Corporation electricity works, England, which were erected from the designs and under the superintendence of the writer, are situated on the north bank of Brayford Pool, a sheet of water about eleven acres in extent forming the junction of the Foss navigation (from Lincoln to the river Trent) and the river Witham, and which discharges through the river Witham to the sea at Boston. The site was chosen with the double object of placing the works as near the centre of the city as possible and to enable full use of the Pool to be made for condensing purposes. No useful purpose is served for the carriage of coal on account of the number of competing railways which run into Lincoln from South Yorkshire and the counties of Nottingham and Derby.

If any borings had been taken of the site before it was acquired and submitted to engineers acquainted with the nature of the requirements of electric lighting works, it is doubtful if their approval of

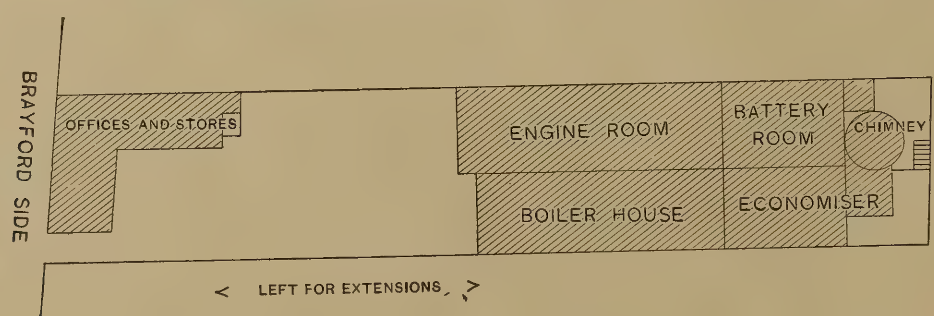


FIG. I

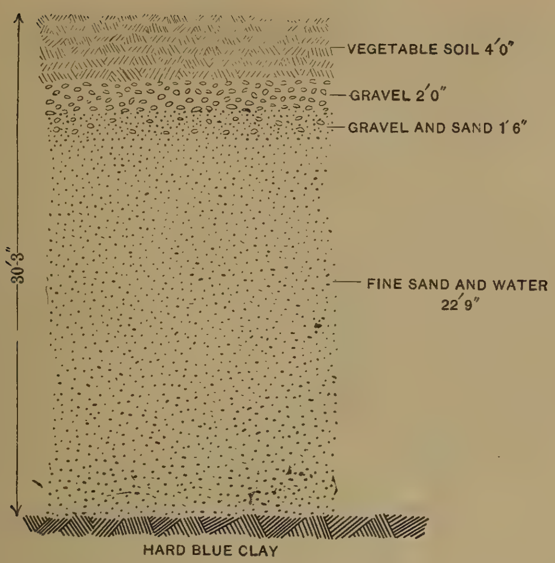


FIG. 2

its choice would have been secured, as it was found, when the vegetable soil and gravel had been removed, that there were about 24 feet of fine sand and water to go through before reaching the clay. When this was discovered, the writer made considerable inquiries to find out what had been done in all the large flour mills, grain stores, malting houses, and other structures which line the Brayford side, and found that they were all practically built on the top of the shallow gravel bed shown in Fig. 2. In no case could it be discovered that any attempt had been made to excavate below this, though in the case of a large church which stands rather further from the river side, it was stated that the clay had been reached.

As it was of vital importance that the arrangement of the machinery in the works should be such as to allow of at least 3000 H. P. being placed there, the writer decided that it was absolutely necessary to construct the foundations and flues in this sandy stratum and practically float the whole building. Fig. 1 shows a block plan of the works. Owing to the delays caused by local government and Board of Trade inquiries, about eighteen months elapsed between the acquisition of the site and the commencement of the erection of the buildings, and the corporation determined, on the writer's advice, to put in the chimney stack foundation and allow it to thoroughly find its own bed. Fig. 3 shows a plan and section of this. It was practically a raft of girders and concrete about 6 feet thick by 35 feet square, thrown in from a height of 9 or 10 feet after a large quantity of flat slabs of limestone had been allowed to settle themselves in the sand. At the four corners of this block, which weighed nearly 400 tons, were fixed four rivets, and levels were taken periodically to ensure that if the block was settling at all, it was at least settling evenly. As a matter of fact, the settlement was infinitesimal. Before passing from the consideration of the chimney block it may be of interest to state that during the construction of the stack, two theodolites were used at right angles to each other, adjusted to fixed points on the adjacent buildings, and the chimney was kept quite central to the foundation block to ensure that the whole mass, estimated to weigh about 1350 tons, should be quite plumb and level, and at certain points small pieces of white glazed brick were built in for test-

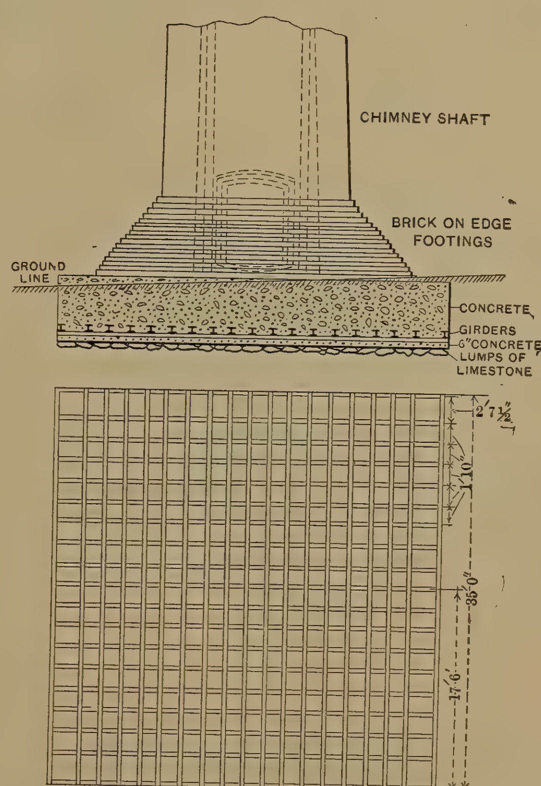


FIG. 3

ing the chimney in the future. The construction of the foundations, flues, and aqueducts for the condensing water is shown in Figs. 4 and 5. As will be seen, a fair proportion stands below the permanent water level, and in flood times the height to which the water rises in the Brayford and the surroundings is very nearly level with the top of the block of concrete placed right across the engine house. The excavation was made in lengths of 10 or 12 feet, and the procedure in the case of the deeper foundations and flues was to lay as quickly as possible, when the required depth was reached, a double or treble layer of 3 ft. × 2 ft. × 3 in. concrete flags and then a slight layer of concrete. When this had been done, all fear of the boiling sand working its way up through the concrete had disappeared and it remained only to deal with the sides, which were held up by the usual wooden planking and struts.

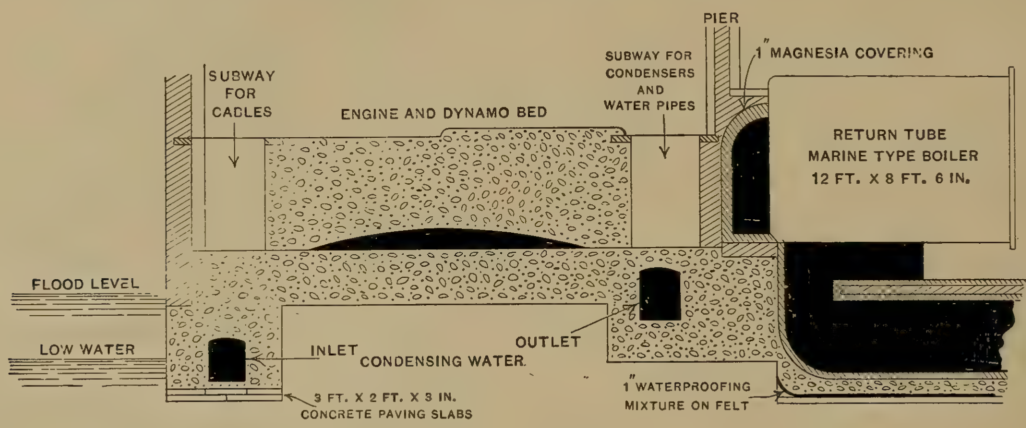


FIG. 4

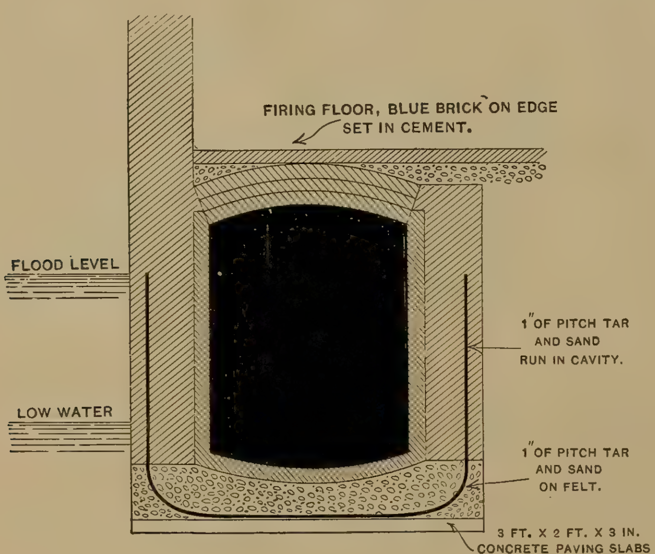


FIG. 5

In the case of the flues, it was absolutely necessary to ensure that no water entered to spoil the draught, and this was done by means of a mixture of 1 part of pitch, 2 parts of sand, and ½ part of gas tar, previously melted together into a paste and poured on to two layers of thick roofing felt, being placed on the thin layer of concrete. That this arrangement was efficacious is shown by the fact that the flues are as dry as the proverbial bone. It was found when some extensions were made to the first portion, about twelve months after they had been constructed, that the waterproofing mixture had thoroughly glazed the brickwork, and it proved a most difficult matter to remove the end wall of the flue for the purpose of adding the required new length.

The concrete mixture in all cases was composed of 2 parts of gravelly sand, 4 parts of broken brick and stone, and 1 part of Portland cement, and the whole of the walls of the building was constructed with mortar made up of 2 parts of sand and 1 of Portland cement. Men-

tion might be made of the combustion chamber at the back of the boilers. It was found that in order to allow of a boiler 12 feet long being removed at any time the space between the front of the smoke-boxes of the boilers in position and the boiler house wall would admit of this being done only if the combustion chamber was recessed into the centre wall between the two rooms, and in order to provide sufficient stability to the structure, piers were arranged for between the ends of the boilers, and the walls were carried on arches sprung from the tops of these piers. The fire-brick lining of the combustion chamber was separated from the wall of the passage-way containing the water pipes and condensers by 1-inch slabs of magnesia, which proved sufficient to keep down the temperature of the outside of this wall, due to the heat of the furnace gases, to about 90° Fahr.

Current Topics

THE late General George B. McClellan, U. S. A., is credited with having made the statement many years ago that the sinking of clams into the sand along the ocean shore by closing their shells and ejecting the water from them in a thin stream, first suggested to him the use of the water jet as an aid in sinking piles in sand. At any rate, as long ago as 1852 a water jet was so used, by General McClellan's advice, in putting down piles for a wharf and warehouse. Water was forced through an ordinary rubber hose, with a piece of gas pipe on the end for a nozzle. This was placed close to the point of the pile on the bottom, the jet of water scouring the sand away from the pile and making a hole, in which the pile sank rapidly. From that time on, as recently recorded in a paper by L. Y. Schermerhorn before the Engineers' Club of Philadelphia, the water jet method has been similarly employed in many different places by different persons. In the United States, in the improvement of the Mississippi and Missouri rivers, large numbers of piles have been driven for the construction of the brush and pile-dikes, and in the sinking of these piles the water jet has been in use since 1881. A great variety of experiments were undertaken upon this work to establish the best details for the use of the jet. This experience demonstrated certain fundamental principles as contributing essentially to the best results, prominent among which were the following:—That the water jet cannot be relied upon to give satisfactory results in material con-

taining a large percentage of gravel; that it should be capable of such concentration of its force as will permit the stream to be delivered through a nozzle not more than 1½ inches in diameter, and frequently somewhat less, and with pump power capable of giving a nozzle-pressure of from 75 to 150 pounds per square inch; that in sand free from gravel the best results are obtained with the larger nozzle and reduced pressure, while the presence of gravel required the smaller nozzle and higher pressure.

GENERALLY, upon the work at the localities referred to, the wrought iron pipe connecting the nozzle with the hose was attached to the side of the pile by two light staples, the lower one about 2 feet above the point of the pile, and the upper staple near the top of the pile, with the nozzle of the jet, which was simply a short piece of pipe, projecting from 6 inches to 1 foot below the point of the pile. After the pile was in place, the jet pipe and attached nozzle were detached from the pile by forcibly withdrawing the pipe from the staples by a light block and fall. In some cases the jet pipe was not attached to the pile, but was worked up and down alongside of the pile as it descended. It was found that the turning and shaking of the pile facilitated its descent; when this failed, the pile-hammer was lowered upon the pile, and either under its weight, or by light blows with about a 2-foot fall, the pile was driven to its final penetration. Upon the work under consideration the piles were generally driven butts down, and were very bluntly sharpened, if at all. These piles were subjected to severe lateral strain by the currents, and therefore the butt ends were driven for the purpose of giving the pile the greatest possible diameter where it entered the ground. An engineer upon this work states that the piles were usually driven from 13 to 20 feet into the river-bed, and that the actual time of driving was about four minutes each, though not more than half of this time was required when the resistances to the pile were small, the first 10 feet being frequently driven in less than one minute. In a short time after the piles had been sunk the sand settled firmly around them, and they became as securely fixed as though driven by a drop-hammer. Various suggestions and experiments have been made relative to securing the action of the water jet on a line coincident with the vertical axis of the pile, and while such efforts have been ingenious, experience has demonstrated that they did not secure greater efficiency than that obtained by placing the jet alongside of the pile in the manner previously described.

IT is not to be assumed that the water jet is the best method to be adopted in all, or even a majority of cases, where piles are to be driven; but in suitable soils it may properly supplement the ordinary method, with marked advantage. With piles which are required to carry considerable vertical loads the action of the hammer should be relied upon to determine the ultimate refusal of the pile to penetrate any further. The water jet permits the piles to be placed with more exactness as to position than the ordinary method, and in driving sheet-piling an intimate contact between the several piles can be obtained. This cannot be secured by the ordinary method in driving sheet-piling in sandy soils. In driving piles into or through heavy material underlying a considerable depth of sand the use of the water jet will temporarily remove the frictional resistance of that part of the pile passing through the sand and thereby permit the hammer to concentrate its work upon the penetration of the pile into the heavy material below the sand. Without the use of the jet this frictional resistance of the sand would cause the pile to declare refusal at a less depth of penetration into the lower stratum of heavy material. Again, the use of the water jet largely removes the destructive effect of the hammer blows upon the material of the pile, and leaves its fibre in a better con-

dition to resist both stress and decay. For the same reason it permits the use of piles of soft wood, where otherwise hardwood piles would be required to withstand the hammer blows in heavy driving, and this frequently is a marked economy in the cost of the work.

LEST we grow too enthusiastic over the steam turbine as an engine for all-around ship propulsion, because of the remarkable performances obtained with it in the torpedo-boat destroyer *Viper*, it is well to bear in mind that this type of motor has economy limitations of a kind which would make it of doubtful value as main driving machinery in warships. It is well known, for example, as the London *Engineer* says in a recent issue, that for all steamships there is a speed of engines and ships which is more economical than any other speed, but with reciprocating engines running at moderate speeds,—anywhere, that is to say, between 60 revolutions for a tramp and 300 revolutions for a torpedo destroyer, there are wide margins within which variations will very little affect the result. Thus, for example, a torpedo destroyer running at ten knots, will probably burn less coal per horse per hour than will be used when she is running at twenty knots, and a good deal less than when she is running at thirty knots, but even then the differences are not large. With the turbine, however, the case is different. With such a boat as the *Viper* it is all or nothing. At extreme speed she may beat the reciprocating engine in steam consumption per horse per hour; but at any other speed the turbine loses, and at half speed or thereabouts economy goes to pieces. Not only is the engine wrong, but the propellers are wrong. It is not contended that this fact is one greatly to the detriment of the turbine engine. Nothing of the kind. The only effect that a fixed and extremely contracted relation between speed and economical efficiency has is that it narrows the limits of application of the turbine engine. Such an engine, for example, might be in every way satisfactory for steamers running between Dover and Calais, Holyhead and Dublin, or even between Liverpool and New York, while it would be wholly unfit for a man-of-war. In the first cases the speeds are always the maximum practically possible, and there would be no difficulty in designing engines to suit. In the navy the speeds are wholly various, and for various speeds the turbine steam engine is not suited. All things considered, therefore, it is by no means improbable that the turbine steam-engine will be largely adopted in the mercantile marine for special high-speed services of the ferry type, such as the Atlantic passenger trade, but not for warships.

WHEN, in the early nineties, a couple of Corliss locomotives were introduced for regular running on the Paris & Orleans Railway, in France, there was little reason to suppose that they would leave pleasant memories behind, and it seemed fairly safe to predict that their period of service would be short. The unexpected, however, has again happened in this instance. It appears that there are now quite a number of these locomotives at work, and in a recent report upon careful tests of one of them against a slide-valve engine of the same size, it was shown that they save from 9.2 per cent. to 16.25 per cent. of water, depending upon the service, compared with a slide-valve engine of the same size carrying the same steam pressure. Another engine in one year saved 15.2 per cent. of coal, compared with the average of eighteen slide-valve engines. The four-valve engine was faster than the slide-valve engine, and often ran at the rate of sixty-seven miles an hour with a train of 184 tons, which the other engine could never do. The common engine did 14,343 foot-pounds of work with one pound of steam, and the four-valve engine 15,721 foot-pounds on the average. The steam pressure of both engines was 142 pounds. But however flattering in one sense, these figures do not tell the whole story. Nothing is

said of maintenance and repairs, though in these items the whole difference between success and failure might be found.

So far as the utilisation of electric energy from storage batteries is concerned, for propelling vehicles which themselves carry the batteries, the key to probably general success is to be found in reduction of weight of battery. Apropos of this, Professor Thurston, in a recent lecture at Cornell University, said that when the battery weighs from five to ten, or even fifteen, times the theoretical weight, and its cost is from five to ten times that of the material from which it is made, it is obvious that, if of any use at all for transportation purposes to-day, it should, in time, when these obstacles to its introduction are in some measure removed, find comparatively frequent and extensive employment. It is probable that a more intelligent and liberal policy on the part of the holders of the monopoly of their manufacture will lead to a reduction of price to one-third the present tariff and still afford good profit, while so enormously increasing their use as to give largely increased dividends to their makers. Weights can probably be, in time, reduced to a fraction of those now usual, and costs should not be more than double those of the raw materials of their manufacture.

The lightest batteries to-day store about 30,000 foot-pounds per pound; coal stores 10,000,000,—of which, however, but about 10 per cent. is thermodynamically transformable, — and heated water stores about a fiftieth of that figure. The heavy storage batteries of the market, proportioned for durability, store but about 20,000 foot-pounds per pound weight. From one third to one-half the total weight of the storage battery outfit, as commonly constructed, is acid, tank, and lining. Both cell and accessories are undoubtedly to be greatly lightened with later improvement. The real question of interest to us now is to what extent we may be able to profit by such improvement in the early future. Just now we must reckon on a weight of not far from 70 per cent., as a maximum, of lead to cell-weight, and sixty to seventy pounds of cell per horse-power-hour, stored in a space measuring not far from one cubic foot, minimum, one and a half as a maximum, per horse-power-hour, although automobilists' demands have, in special cases, brought the space down to a half cubic foot, and still less is promised. For similar quantities of power and work, at the point of application to propulsion, the storage battery has a weight of fifty to a hundred times as much as coal, and demands from ten to twenty-five times as much space.

In discussing tall buildings recently before the American Society of Civil Engineers, Captain Robert W. Hunt supplied some data concerning one of Chicago's representative buildings of this type which afford a striking measure of the magnitude of these modern building enterprises. From the historical fact that the ground on which this building now stands was formerly occupied by such rattle-trap affairs that it was known, the city over, as the "Rookery," it was called "The Rookery" by the capitalists who secured the land from the city on a ground rent of ninety-nine years. It is a building which will compare very favourably with any in the United States, although it was one of the first high office buildings. It is recognised from its location, history, and associations as probably the most desirable building in Chicago, and as it can hold only a certain number of people, tenants have to pay probably the highest rent charged by any of the buildings in the city. There are 3200 people in the building. Its cost was about $1,800,000, and from its inception to the present time it has never paid its owners less than 12 per cent. on their investment, which makes it rather a profitable

one for them. There are ten passenger elevators, or lifts, and one freight elevator, and the check which has been kept upon the number of people riding in them at different times shows that as many as 22,000 and 23,000 per day have been carried. Of course, that number does not represent different individuals, but the number of passengers carried. Every one living above the first story probably takes four rides a day, in addition to which there are business visits between the offices, and people coming to see the occupants. "The Rookery" is a town within itself. It has in the basement its own power plant, its own pumps, its own heating arrangements, its own electrical service. It has its own carpenters, its own painters, its own plumbers, and every mechanic necessary is employed in the building permanently. They start from the roof and work down to the ground as regularly as the years roll on. By the time they reach the ground itself or the basement, the top of the building is in a condition to need their work once more, and they repeat the process, so that the building, after its twelve or thirteen years of life, is practically as good as it was on the day it was built.

As one of the most notable examples of the advance that has been made in the traffic requirements of American railways during the past twenty years, the *Railroad Gazette* cites the rebuilding of the famous Kinzua Viaduct, on the Bradford Division of the Erie Railroad. At the time of its construction in 1882 this viaduct was one of the notable structures of the world, exceeding both in height and length anything of its kind that had, up to that time, been built. It was designed to carry the heaviest engines and cars that were in use, and was admirably adapted to the purposes for which it was intended, this purpose being carrying the soft coal traffic of a section of Northwestern Pennsylvania to the connection of the Bradford Division with the main line of the Erie at Carrolton. But the increase of car capacity brought about by the introduction of the steel car, coupled to the engines of enormous power that are now used to haul them, has added stresses that the structure was incapable of sustaining. The result has been that the viaduct, built eighteen years ago, and which has suffered no appreciable deterioration, has been torn down to its foundations, and a new one, capable of carrying modern traffic, has been built. In the old viaduct the height of the base of the rail above the water level of the stream in the bottom of the valley was 301 feet, and the total length of the structure was 2053 feet.

In 1882 the consolidation locomotives used in the coal traffic weighed 103,400 pounds, of which 88,700 pounds were on the driving wheels, 48 inches in diameter, having a rigid wheel base of 14 feet 9 inches, and a total of 22 feet 10 inches. The boilers carried a pressure of 125 pounds per square inch, and the cylinders were 20 inches in diameter, with a piston stroke of 24 inches. The cars that these engines were hauling averaged a capacity of 40,000 pounds, with a leaven of a few of 50,000 pounds capacity, and with those of 60,000 pounds just common enough not to excite undue attention. This traffic the viaduct has carried for many years; but the new conditions imposed are that cars of 100,000 pounds capacity shall be run in trains hauled by engines of the consolidation type weighing 190,000 pounds, of which 170,000 pounds are on the driving wheels of 57 and 64 inches diameter, with a rigid wheel base of 15 feet 9 inches and 17 feet, and a total wheel base of 24 feet and 25 feet 3 inches. The boilers carry a steam pressure of 200 pounds per square inch, and the cylinders are 21 inches in diameter, with a piston stroke of 28 inches. Speaking roughly, the car capacities have increased from 100 to 150 per cent., engine weights have gone up 83¾ per cent., and the cylinder capacity of the modern engine is 18 per cent. greater than that of the heavier engines

of two decades ago, so that in the combination of steam pressure and cylinder capacity the motive power has been increased between 75 and 80 per cent.

How rapidly the aluminium industry has developed in recent years is very well shown in the tabulated statement below, given a short time ago by Mr. Joseph A. Steinmetz in the course of a lecture delivered before the Franklin Institute. It shows the aluminium production of the world during the past dozen years, expressed in tons of 2000 pounds, and also of the United States separately, the latter figures having a special interest in view of the fact that it is in the United States and in France that the industry is making most progress.

	United States.	World.	Per cent. in United States.
1889	21.6	70.9	30
1890	27.9	165.3	17
1891	68.2	233.4	29
1892	118.1	487.2	24
1893	154.4	716.0	22
1894	250.0	1,240.9	21
1895	417.3	1,418.2	29
1896	590.9	1,659.7	36
1897	1,814.4	3,394.4	53
1898	2,358.7	4,500.0 (est)	52
1899	2,948.4	6,000.0 (est.)	49
1900	4,000.0 (est.)	7,500.0 (est.)	53

Those returns marked estimated (est.) are the best which can be conjectured from available data. It is expected that Canada will enter the list of producing countries this year, with a plant of 5000 horse-power, and will add 1000 tons each year to the world's output. Presuming that the total amount of aluminium produced in 1899 was used for the specific purpose of electric conductors, then the 6000 tons of aluminium would displace 12,000 tons of copper, or a like amount of aluminium sheet would be equivalent to 20,000 tons of sheet copper, were the specification for culinary and cooking utensils. These comparative figures emphasise the important position that the metal has assumed. It may not be amiss to add here that the plants now producing aluminium are those of the Pittsburgh Reduction Company, at New Kensington, Pa., and Niagara Falls, N. Y.; the British Aluminium Company, in Great Britain; the Aluminium Industrie Aktien-Gesellschaft, at Neuhausen, at the Falls of the Rhine, in Switzerland; the Société Electrometallurgique Française, at La Praz, and the Société Industrielle de l'Aluminium, at St. Michel, in France. There are also several large plants projected and in course of construction, notably upon the St. Lawrence River, in Canada, and at Rheinfelden and Salzburg, in Germany.

THE days of the old-fashioned link and pin coupler on railways are rapidly coming to an end, at least in the United States, where the adoption of the automatic coupler has been wisely hastened by national legislation. So much progress has, indeed, been shown in changing the equipment there, that railway supply houses which once handled the link and pin coupler in carload lots and kept large stocks on hand to meet the steady demand, now find their orders calling for a few at a time, and even such orders are comparatively far apart. Modern rolling stock harmonises but poorly with the antiquated device which probably would have been supplanted in due course by the automatic coupler even without a compulsory law.

EVERY one now is aware that in the Marconi system of electric wave telegraphy an important feature is the employment of an elevated conductor which generally takes the form of a wire suspended from a mast. When Marconi attracted attention by his feat of establishing communication across the English Channel without wires the argument was raised against its commercial utility that a wave or signal sent out from one transmitter would affect equally all received within its sphere of influence, and hence the privacy of the communication would be destroyed. Concerning this Professor J. A. Fleming said recently in the London *Times* that no one felt the force of this objection more

strongly than himself. For the last two years he has not ceased to grapple with the problem of isolating the lines of communication, and success has now rewarded his skill and industry. Technical details must be left to be described by him later on, but meanwhile it may be said that he has modified his receiving and transmitting appliances so that they will respond to each other only when properly tuned to sympathy. Other inventors have claimed to be able to do the same thing; but, says Professor Fleming, no one has given practical proof of possessing a solution of this problem which for a moment can compare with that Mr. Marconi is now in a position to furnish.

THE experiments have been conducted between two stations thirty miles apart, one near Poole, in Dorset, and the other near St. Catherine's, in the Isle of Wight. At the present moment there are established at these places Mr. Marconi's latest appliances, so adjusted that each receiver at one station responds only to its corresponding transmitter at the other. During a three days' visit to Poole, Mr. Marconi invited Professor Fleming to apply any test he pleased to satisfy himself of the complete independence of the circuits, and the following are two out of many such tests:— Two operators at St. Catherine's were instructed to send simultaneously two different wireless messages to Poole, and without delay or mistake the two were correctly recorded and printed down at the same time in Morse signals on the tapes of the two corresponding receivers at Poole. In this first demonstration each receiver was connected to its own independent ærial wire hung from the same mast. But greater wonders followed Mr. Marconi placed the receivers at Poole one on top of the other, and connected them both to one and the same wire, about 40 feet in length, attached to a mast. Professor Fleming then asked to have two messages sent at the same moment by the operators at St. Catherine's, one in English and the other in French. Without failure each receiver at Poole rolled out its paper tape, the message in English perfect on one and that in French on the other. When it is realised that these visible dots and dashes are the results of trains of intermingled electric waves rushing with the speed of light across the intervening thirty miles, caught on one and the same short ærial wire, and disentangled and sorted out automatically by the two machines into intelligible messages in different languages, the wonder of it all cannot but strike the mind. During the same demonstrations messages were received from a transmitter thirty miles away and recorded by an instrument in a closed room merely by the aid of a zinc cylinder, 4 feet high, placed on a chair. Whilst these experiments have been proceeding between Poole and St. Catherine's others have been taking place for the British Admiralty between Portsmouth and Portland, these lines of communication intersecting each other; yet so perfect is the independence that nothing done on one circuit now affects the other, unless desired. A corollary of these latest improvements is that the necessity for very high masts is abolished, and Mr. Marconi has established perfect independent wireless communication between Poole and St. Catherine's by means of a pair of metal cylinders elevated 25 or 30 feet above the ground at each place.

NATURAL gas in the United States, according to the last annual report of the United States Geological Survey, has sunk to about one-third, in its fuel value, of what it was a few years ago. In 1899 the production of natural gas equaled in consumption the heating capacity of 5,400,000 tons of coal. Ten years ago, when this industry was at its height, the equivalent of the heating output of natural gas was equal to about 15,000,000 tons of coal. Both the great gas-producing fields are reaching extinction. The Ohio division, which once had 480 pounds to the square inch, has now no rock pressure whatever.

The original rock pressure in Indiana, once 325 pounds, averages now 165 pounds, showing that two-thirds of the product has been taken out and consumed. Over a very considerable area of Indiana, covering an area of about 1500 square miles, industries which were using natural gas are either discontinued, working at a disadvantage, or substituting coal. The effect of this is plain in various directions, particularly in reduced business and opportunities for labour in part of the State. The aggregate value of the gas produced in 1899 was $20,024,864, a gain of $4,730,051 over 1898. This is in part due to a slight increase in the cost, but still more to an increased demand.

SAMUEL T. WELLMAN,

PRESIDENT OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

A BIOGRAPHICAL SKETCH

IN the engineering profession Mr. Samuel T. Wellman, the newly-elected president of the American Society of Mechanical Engineers, has long been a conspicuous figure. In 1851, when he was four years old, his father moved to Nashua, N. H., and entered the employ of the Nashua Iron Company, of which works, a few months later, he was appointed superintendent. This position he occupied for about twenty-seven years. Mr. Wellman was educated in the common schools at Nashua, one year of his time being spent at the High School. He had also one year's schooling at the Norwich University at Norwich, Vt., from 1862 to 1863, but most of his education was acquired in the iron works and the machine shop. He served one year as an apprentice in the machine shops of Messrs. Gage, Warner & Whitney, at Nashua, and also served one year in the army,—from 1864 to 1865,—in the First New Hampshire Heavy Artillery.

After his discharge, he was engaged for about two years in the works of the Nashua Iron Company in various capacities. At the end of that time he was serving as a draughtsman and engineer, and built the first Siemens gas regenerative heating furnace which was put into operation in the United States. A few weeks after the drawings had been received, Messrs. Siemens sent an engineer, Mr. J. T. Potts, from England to build the furnace, but upon his arrival at the works in Nashua he was very much surprised to find the furnace finished and ready for work. He was so well pleased with the work which Mr. Wellman had done that, after the furnace was started, he made him an offer to assist him in the erection and starting of Siemens furnaces in the various works in America, an offer which he very quickly accepted. The American agents of the Siemens patents at the time of Mr. Wellman's engagement were Messrs. Tuttle, Gaffield & Co., of Boston, but soon after they sold out their business to Messrs. Richmond, Potts & Loring, with which firm Mr. Wellman was employed for nearly three years. Most of the time he was in their employ was spent at Pittsburgh, Pa., where he built and started crucible steel melting furnaces at the works of Messrs. Anderson, Cook & Co. and Singer, Nimick & Co. He erected also a pair of regenerative gas puddling furnaces at the Eagle Iron Works.

When he first went to Pittsburgh in connection with this work, he made up his mind that he would lose no opportunity to learn all there was to be learned of the manufacture of steel, and he spent all the time he could get in studying the different operations, storing away the information so gained for

future use. After he left the employ of Messrs. Richmond, Potts & Loring, in 1869, he was employed by the late Mr. C. P. Haughian, president of the Chrome Steel Works, of Brooklyn, N. Y., to build for them a Siemens regenerative crucible steel melting furnace. This furnace was built and started, and was so successful that Mr. Haughian warmly recommended Mr. Wellman, and he was engaged by the late Ralph Crooker, at that time superintendent of the Bay State Iron Company, in Boston, to design and build for that company a furnace for melting steel on the open-hearth plan. The only data available and experience from which to build this furnace had been gained in the building of a small experimental furnace by Messrs. Cooper, Hewitt & Co., of Trenton, N. J., who had bought the Martin patents for America and built a small furnace to test their value.

The furnace at the Bay State Works was the first open-hearth furnace in the United States to make steel on a commercial scale. It was successful from the very start and operated for many years. It had a very novel casting arrangement. No ladle was used, but the steel was tapped direct from the furnace through a fore-hearth into the moulds, which stood on a turn-table in front of the furnace, the stream being regulated by a fire-clay-covered stopper in exactly the same manner as practiced in all steel works with a ladle. This fore-hearth has lately been applied by Mr. Wellman with great success to the large fifty-ton furnaces at the works of the Tennessee Coal, Iron and Railroad Company, at Ensley, Ala.

From the Bay State Iron Works Mr. Wellman went back to the works of the Nashua Iron Company, where he held the position of engineer and assistant superintendent from 1870 to 1873, his father still being superintendent. During that time he designed and constructed an open-hearth steel plant, a three-high plate mill, and a bar mill for rolling merchant iron. In the fall of 1873 he had a very tempting offer to leave the works of the Nashua Iron Company and build a new steel works at Cleveland, Ohio. After going there and looking the ground over, he concluded to accept the position, and, in September of 1873, moved his little family to Cleveland, where he was engaged by the Otis Steel & Iron Company to design and build their new works. They started on a new piece of ground, and built an open-hearth steel plant, a plate mill, and a large and small bar rolling mill. At his suggestion, during the building of the works, and for two or three years afterwards, the late Alexander L. Holley was engaged as consulting engineer. Mr. Wellman was entirely responsible for the designing of the works, and the whole management, mechanically and metallurgically, was in his hands for sixteen years.

The reputation of the steel turned out by this works while under Mr. Wellman's management is too well known to need repeating at this time. During the last part of his connection with the Otis Company the most that any of their competitors was known to claim was that their steel was equal to "Otis steel." It was acknowledged as the standard for that class of metal. Early in the spring of 1886 Mr. Wellman rebuilt one of the furnaces at the Otis Works, putting in a basic bottom, which was made of magnesite imported from the Carl Spaeter Works at Coblenz. This furnace was operated only for a few months, but during that time they made quite a large amount of basic steel, which was the first ever made in this country. Owing to the limited capacity of the Otis Works and the great demand for their regular product of acid steel, the basic process was discontinued, and the experiments which they had made were kept a secret. Mr. Wellman, however, was much impressed with the process, and prophesied that basic open-hearth steel would soon supersede acid steel, and would, in time, entirely replace the acid Bessemer process; and to-day nearly all of the open-hearth steel in this country is made by the basic process, and the method of manufacturing is almost precisely the

same as that followed by him at the time mentioned.

He severed his connection with the Otis Company on January 1, 1889, and a few months after leaving them became consulting engineer for the Illinois Steel Company, designing for them the open-hearth steel works and plate mill now running at the South Chicago works of that company. The following year he became interested in a company which bought the old works of the Chester Rolling Mills Company, at Chester, Pa., he becoming president of the company. This was an unfortunate move for him, but possibly a good experience. Added to the difficult problem of remodeling an old works, was the still more difficult one of running it at a profit on a rapidly declining market. Combined with the other troubles, was a want of harmony among the stockholders, which culminated in the stronger party, who also held the mortgage on the company, forcing the company into bankruptcy. Soon after this Mr. Wellman moved back to Cleveland, and, in company with his brother, Mr. Charles H. Wellman, and Mr. John W. Seaver, organised the Wellman-Seaver Engineering Company. This company has been phenomenally successful, and has been employed as engineers and contractors, mostly in connection with steel works, all over the world. The greater part of the work has been done in the United States, but much has also been done in Great Britain, Germany, Spain, Russia, France, and also for a new government steel works in Japan.

Mr. Wellman has taken out a great many patents, the most successful and best known being the Wellman hydraulic crane and the Wellman open-hearth charging machine. This machine has done more to lower the cost of open-hearth steel making than any other invention since the Siemens furnace was invented, the direct saving to the users of the machine in the United States for the year 1900 amounting to not less than one million dollars; indirectly, it amounted to more than twice that amount. The Wellman gas producer also is well known, and many hundreds of them are in use all over the United States. A novelty in the way of open-hearth steel melting furnaces is the rolling open-hearth furnace, which has been built in very large sizes. The first furnace in the world of fifty tons capacity was of this type, and was built at the works of the Illinois Steel Company.

Mr. Wellman has been connected with several companies besides those thus far mentioned. The Solid Steel Company, of Alliance, Ohio, a very successful works for the manufacture of steel castings, since sold to the American Steel Castings Company, was of his inception, and he was for many years a director and its largest stockholder. He was also a director and stockholder for many years in the Americcn Wire Company, of Cleveland. He is a member of the American Society of Civil Engineers, the American Institute of Mining Engineers, the British Iron and Steel Institute, the British Institution of Mechanical Engineers, the Verein Deutscher Eisenhüttenleute, and of the American Society of Mechanical Engineers, over the deliberations of which he will preside during tbe coming year.

PHOTO BY NOTMAN PHOTO CO., BOSTON

Elihu Thomson

SEE PAGE 318

CASSIER'S MAGAZINE

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A NEW WATER POWER TRANSMISSION PLANT

CARRYING POWER FROM APPLE RIVER TO ST. PAUL, U. S. A., AT 25,000 VOLTS

By Charles L. Fitch

OF all the streams which water the western plateau of Wisconsin, U. S. A., there is none more charming than Apple River. Studded with islands and bordered by high bluffs, its ever-changing beauties delight the eye of the visitor. One of its most favoured spots is found at the "Falls," celebrated as much for their romantic scenery as for the descent of the waters. For years they have attracted attention as a possible water-power, but their location, miles from railway transportation, precluded their local use by any considerable manufacturing or milling establishments.

Apple River, at this point, flows through a picturesque valley, expanding out above the river into a plateau several hundred feet in width. The falls proper occupy the centre of this basin, with rapids above and below. For ages they had tumbled by in idle waste, awaiting the touch of applied science to convert them into useful energy. In the summer of 1898 the attention of Mr. Robert N. King, of Dayton, Ohio, one of the foremost authorities on water-powers in the United States, was directed to this locality. He at once appreciated the feasibility of its development on a large scale, by utilising the additional head in the river above and below the falls, constructing a high dam, and transmitting the power electrically to the city of St. Paul, Minnesota, twenty-seven miles distant.

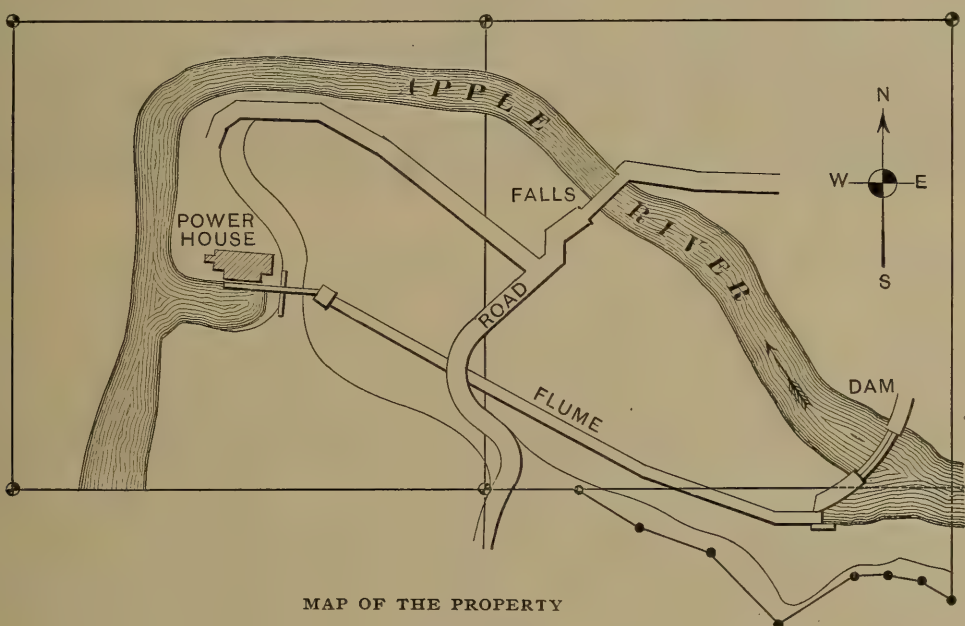
After securing possession of the controlling property, he organised a company for its development, but subsequently, in the summer of 1899, made a contract with the St. Croix Power Company, lessees of the St. Paul Gas Light Company, to make plans, construct the necessary dam, flume, power house, and pole transmission line, install all hydraulic and electric machinery, and turn the completed plant over in readiness for operation, the power to be marketed through the medium of the St. Paul Gas Light Company.

Apple River is peculiarly adapted to water-power development. In addition to a large fall, it has a very uniform flowage, the difference between high and low water being but thirty inches. A natural reservoir exists at and near its source in a number of large lakes, regulating the flow. It has a drainage area of about four hundred square miles,

A BIRD'S-EYE VIEW OF THE PLANT ON APPLE RIVER

and a large minimum flow, being about half a cubic foot per square mile, the rainfall approximating thirty inches per annum.

The country contiguous is, in general, flat and with good depth of soil. The river rises in Burnett County, Wisconsin, and empties into the St. Croix, eight miles above the city of Stillwater. The falls are a mile and a half above its mouth, and have a precipitous descent of about twenty-five feet. By the construction of the dam above the falls, and the location of the turbines at the foot of the widened valley, a total head of eighty-two feet is made available. A general map of the property, showing the location of the dam, flume, penstock, and power house, and the river between the dam and the power house, with the falls about midway, is given on this page.



MAP OF THE PROPERTY

The final contract was signed on August 11, 1899, and before the end of the month construction was begun under the supervision of the writer. The work was pushed forward rapidly, and the major part of the dam was finished before winter stopped operations. An early start was made in the spring, and the month of September saw the completed plant in the hands of the operating company.

The rock formation underlying all that section of country is the "Upper Sandstone." This rock is too porous to permanently resist the action of water, and it was, therefore, decided to construct the dam on a foundation of concrete and to enclose it on all sides in a shell of like material. As the falls are five miles removed from the nearest railway, the difficulties of transportation made the use of building stone from a distance out of the question, and the first problem which presented itself was to provide a suitable stone for concrete. This difficulty was solved by the use of the granite and trap boulders, commonly called "Nigger Heads," which are found over all the country in large numbers near the surface of the ground, and make, when crushed, an excellent material for the purpose.

The dam was built with a sandstone core of uncoursed rubble masonry, laid in Portland cement mortar, consisting of three parts of sand to one of cement, and this was carried to within six feet of the crest of the dam. The concrete for the facings was composed of one part, by measure, of Portland cement, three parts of sand, and four parts of the broken stone above mentioned. The sand and cement were mixed while dry, water was added for tempering, and the whole was then mixed with the broken stone, only sufficient water being use

A VIEW OF THE POWER HOUSE, SHOWING THE TAIL RACE AND THE BEGINNING OF THE TRANSMISSION LINE

to admit of ramming. The stone was crushed into cubes, ranging from one inch to two and one-half inches on a side, and the ingredients for the concrete were mixed by hand. The concrete was conveyed from the mixing floor to its place in the work by a crane, and great care was taken to avoid segregation of the components by rough handling or "shooting" the concrete into place.

The dam was built on a circular arc, having a radius of 450 feet, and is 46½ feet high to the level of the spillway. A cross-section of the spillway proper is shown in the cut on page 253, the darker portions representing the concrete facings, 18 inches thick on the up-stream side and 30 inches on the down-stream side. In the background may be seen the outlines of the wing wall and abutment.

The trenches shown in the river bottom are cut into the solid rock, and extend up the bank on either side, the larger or main seepage trench being six feet in width and eight feet in depth under the foundation. These trenches were filled with concrete and brought up to a level surface two feet above the river bed before the first course of rubble masonry for the core was laid. The ends of the dam were carried about twenty feet into the sandstone bluffs on either side of the river, and constructed of solid concrete, to avoid any chance of a run-around. The length of the spillway is 108 feet, and the total length of the dam, 399 feet, making up 3150 cubic yards of concrete and 5000 cubic yards of rubble masonry.

In the main body of the dam, near the north end, and just above the bed of the river, are placed the two steel pipes, each five and one-half feet in diameter, through which the river flowed while construction was in progress. These openings are now fitted with substantial waste-gates on the up-stream side, and permit the water in the pond to be drawn down should occasion require it. In the view on page 254 these gates are open, and the water can be seen rushing through them to form the river below. A rack and gates at the south end of the dam control the entrance of water to the flume. The bars of this rack are spaced two inches apart.

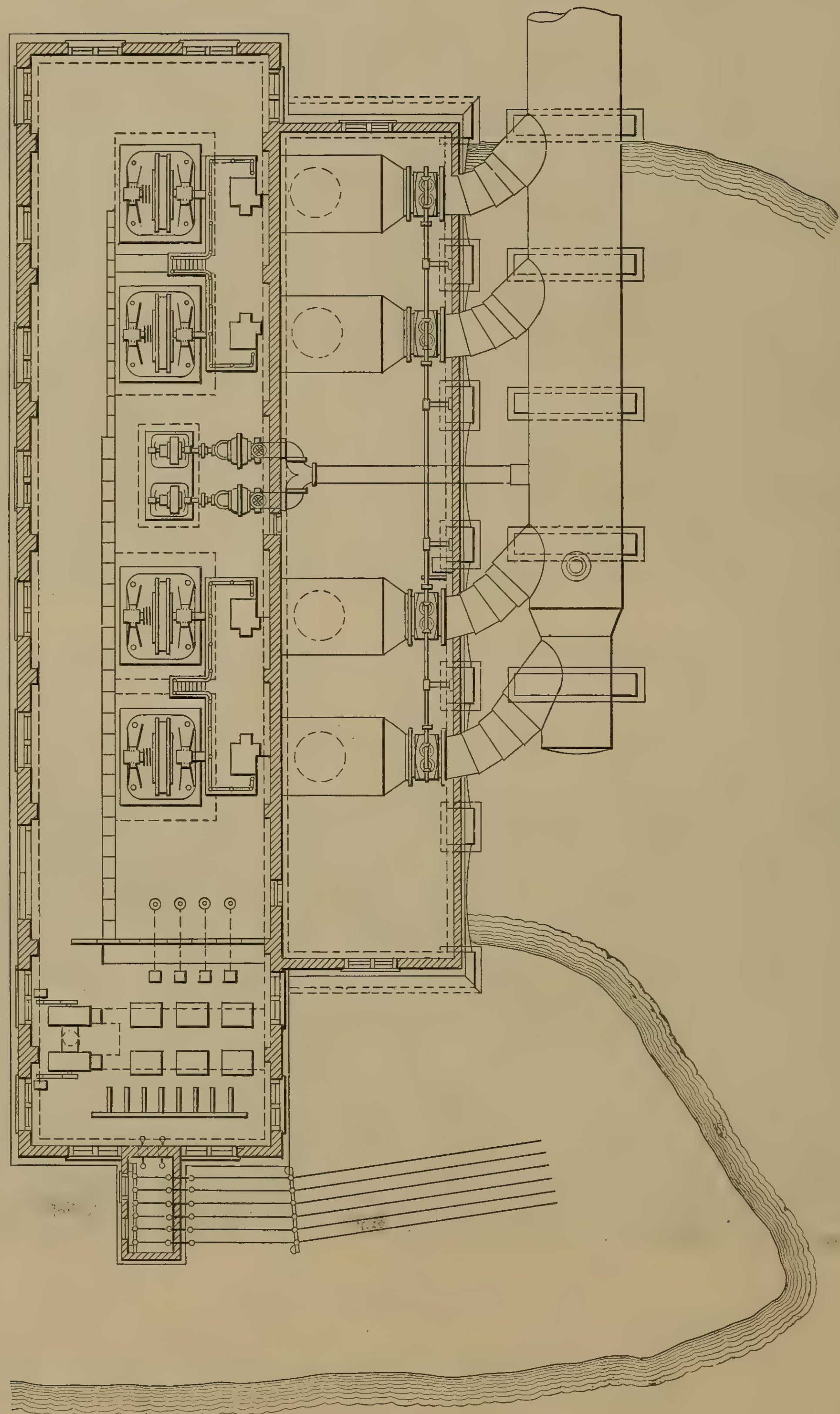
A finer rack is provided in the forebay at the entrance to the steel penstock. The pond behind the dam is about two and one-half miles long, and its area is about 1,250,000 square feet. The right to overflow these lands was purchased from the property owners along the river before construction was begun.

The flume has its beginning in a substantial chamber of concrete at the south end of the dam, and communicates with the pond above through three arched openings fitted with wooden head-gates. Its length is 1550 feet, and, with two slight angles, it runs practically straight from the dam to the forebay. The bottom of the flume is 12½ feet below the level of the spillway. It is absolutely level from end to end, and was designed to carry, with a velocity of 3 feet, 670 cubic feet of water per second, sufficient for about 5000 horse-power with a head of 82 feet. East of the road shown on the map on page 245 the ground is low, and the flume there rests on a bench excavated from the side of the hill. West of the road the ground is higher, and a deep excavation across an intervening plateau was necessary.

The forebay is a self-sustaining steel box, 24 feet square and 17 feet deep. It is situated about 100 feet back from the brow of the hill above the power house, and rests on a bed of concrete. It is reinforced and surrounded by masonry walls 12 feet thick at the bottom. At its upper end the forebay connects with the flume, and its lower end is pierced by the expanded end of the penstock which conveys the water to the wheels below. Here are located the tail-gates and the steel rack to protect the entrance to the penstock. The bars of this rack are spaced 1½ inches. Under the forebay is a concrete seepage wall, 40 feet long across the line of flow, and 10 feet deep, its object being to cut off any water that may leak from the flume and make sure that it shall not follow the penstock down the hill.

The penstock is a riveted pipe, 12 feet in diameter, made of open-hearth steel. From its lower end to a point 37 feet above the tail-race its shell is seven-sixteenths of an inch thick; above this point three-eighths-inch steel is used. Beginning at the forebay, the first 87 feet of the penstock are horizontal. It then extends down the hill 108 feet at an angle of about 45 degrees; it then

ANOTHER VIEW, SHOWING THE PENSTOCK



A PLAN OF THE POWER HOUSE

THE TRANSMISSION LINE ALONG THE COUNTRY HIGHWAY

runs horizontally again 118 feet to the west end of the power house.

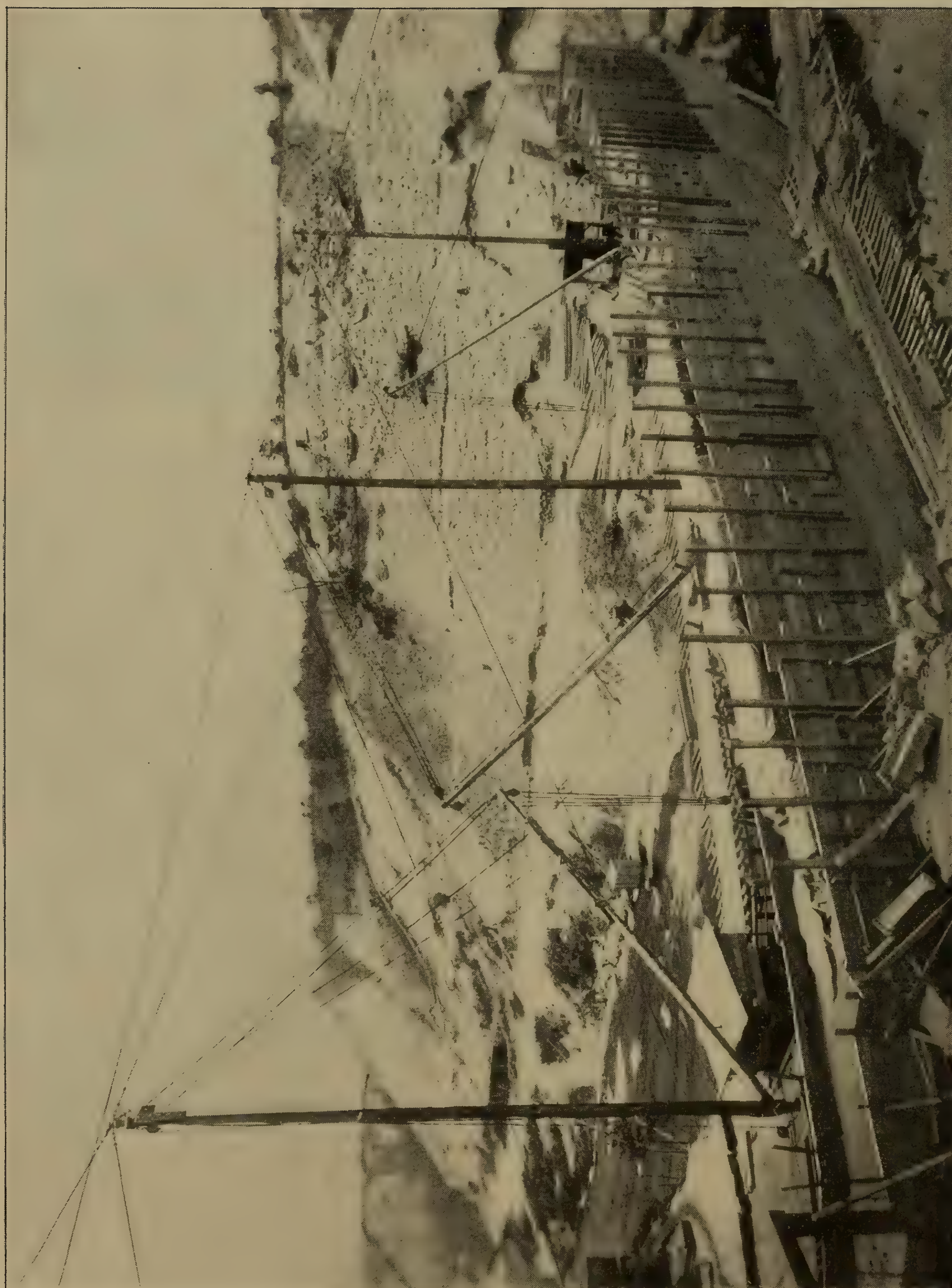
The penstock is held together by seven-eighths-inch rivets, spaced two and one-half inches from centre to centre, and is supported on masonry piers. Where it runs down the hill it is partly embedded in earth, which is tamped around it to give additional support. It is, in part, so nearly vertical that it acts as a stand-pipe, and no stand-pipe proper was found necessary. An air vent was, however, provided at the highest point at the top of the hill, a short stand-pipe 10 feet high being added for this purpose. At its lower end there is an automatic relief-valve.

Located on a flat about 5 feet above the river, and surrounded on all sides by high bluffs, the power house is reached by a flight of a hundred odd steps, extending down the side of the hill. A ground plan of the building and its contents is given on the opposite page. The superstructure is of brick, 144 by 57 feet, with a steel trussed roof, and is supported on substantial masonry foundations. It is divided by a longitudinal brick wall into two rooms.

The larger of these rooms, on the north side, contains the dynamos, switch-boards, transformers, and all other electrical appliances, as well as the water-wheel governors. The south room contains the water-wheels and their accessories. The steel penstock, above referred to, extends along the south side of the building, being supported above the tail-race on masonry piers. Each of its four main branches pierces the south wall of the building and supplies one of the four sets of water-wheels within. A fifth branch, of smaller size, supplies the exciter wheels.

The turbines are of the Victor type, each set consisting of two 36-inch special wheels with bronze runners, mounted horizontally in a cylindrical wheel-chest, 9 feet in diameter by 12 feet long. Both wheels run on the same shaft, which is direct-connected to one of the 750 KW alternators. In each of the four branch feeders is placed a 56-inch gate valve, operated independently from a shaft by a 7½-H. P. electric motor provided for the purpose. The time required to completely open or close one of the gates is seven minutes. There are two exciter wheels, each in its own wheel-chest, with separate gate valve and feeder-pipe connection.

The alternators, four in number, are three-phase, 800-volt, sixty-cycle, revolving armature machines. They have

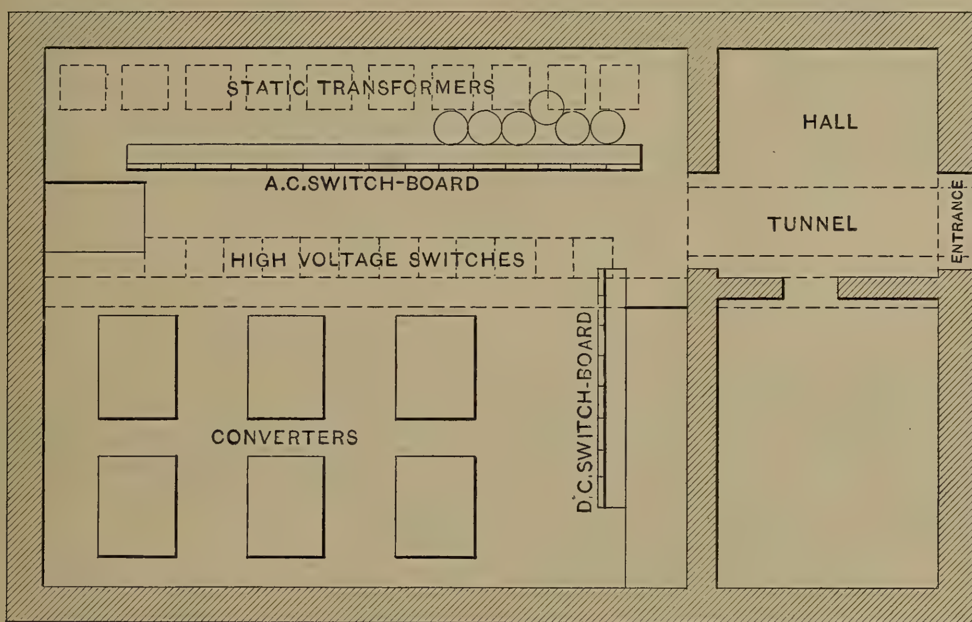


THE DAM DURING CONSTRUCTION

a capacity, as already mentioned, of 750 KW each, are separately excited, and run at a speed of 300 revolutions per minute. They are capable of an overload of 50 per cent. for a limited time without overheating. The exciters are 125-volt, shunt-wound machines, running at 925 revolutions per minute, and each has a capacity of 30 KW, — more than sufficient to excite all four of the alternators. For convenience in operating, the exciter wheels are located in the dynamo room, the exciters being set side by side on the same foundation.

The water-wheel governors, four in number, are located, each upon a raised platform, above and behind the dynamos which they control. They are of the improved Giesler pattern, and a guarantee is furnished by the makers that the speed of the wheel shall not vary 3 per cent. for any change in load not over 25 per cent. of the total load at the moment of variation. The governors are electrically controlled, the necessary current being furnished by the exciters.

The switch-board extends across the dynamo room, about 30 feet from the west end of the building, and is about 22 feet long and 8 feet high. At its south end is the exciter panel, having the usual measuring instruments and switches. Next come the four alternator panels, each having the customary field-switch, synchronising lamp, and voltmeter plugs, as well as an indicating watt-meter, an alternating-current ammeter, and a direct-current ammeter for the field current. Each of these panels is, moreover, provided with a three-pole oil switch and two three-pole, quick-break knife switches, by which any dynamo may be connected to either of the two sets of bus-bars with which the board is equipped. The two knife-switches are in series with the oil switch, and both are between the machine and the bus-bars.



THE TRANSFORMER SUB-STATION AT ST. PAUL

Following these come the two transformer panels, each provided with a recording watt-meter, a potential indicator which gives the volts at the St. Paul end, regardless of the power factor and the drop in the line, and a specially designed oil switch, having a capacity of 1500 KW. The remaining panel contains the switches for controlling the motors which drive the transformer blowers, and for the lighting and heating circuits around the building and grounds. On a bracket at the south end of the board are the two potential indicators, which may be plugged to

either set of bus-bars, or to any one of the machines. The four machine rheostats are set well back behind the board, and are controlled by hand wheels, supported from the floor on pedestals in front.

The wires which connect the dynamos with the switch-board are carried in a shallow trench extending lengthwise of the building, under the floor in front of the machines. The main conductors are lead-covered cables, and the rest are rubber-covered wires. They are laid side by side on a wooden floor at the bottom of the trench, separators of wood being used where necessary. The trench is covered with cast iron plates flush with the floor. Behind the switch-board there is a transverse pit connecting at one end with this trench, and also with the wind chamber under the transformers.

The air-blast transformers are six in number, and occupy the space between the switch-board and the west end of the building. They have a capacity of 500 KW each, and step up the voltage at once from 800 to 25,000 volts. They are connected in two sets of three, with Y connections; each set, therefore, has a capacity of 1500 KW.

The primaries of each set are connected directly to one of the oil switches on the transformer panels of the switch-board, and each of the secondaries is connected with a Westinghouse "spider" switch on the high-tension switch-board, located at the extreme west end of the building. The "spider" switches are nine in number, and are so arranged that either set, or both sets, of transformers may be connected with either of the two high-tension line circuits.

Under the transformers, and connecting with them through apertures in the floor, is the wind-chamber, into which the air blast is forced by two motor-driven blowers. The wind-chamber also serves as a conduit for the low-tension wires between the switch-board and the transformers.

ALONG THE FLUME DURING CONSTRUCTION

The floor of the building is of cement, except for a small portion behind the switch-board and under the transformers, where wood is substituted. Heat is furnished by eight banks of electric

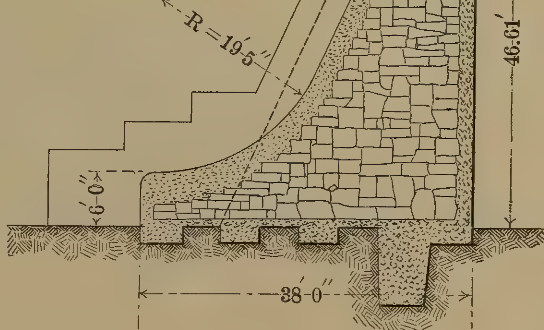
THE FACE OF THE DAM

heaters, and eight enclosed, alternating-current arc lamps, connected in series with a regulator, provide an abundance of light. Both the heaters and the lamps are supplied with current from the 800-volt bus-bars.

The water-wheel governors and turbines were furnished by the Stilwell-Bierce and Smith-Vaile Company, of Dayton, Ohio; the lamps, by the Manhattan General Construction Company, of New York; and all the remaining electrical apparatus, except the "spider" switches and the heaters, by the General Electric Company, of New York. A 20-ton travelling crane is supported on an elevated track, extending from end to end of the dynamo room, and affords a convenient and rapid means of handling the machinery.

Adjoining the west end of the building, and connecting with it by openings in the wall, is the lightning arrester station, from which the electrical transmission line starts on its way to St. Paul. This structure, like the power house, is of brick. It is 14 feet long by 8 feet wide, and is equipped with General Electric Company apparatus. The end of the line is supported on glass insulators on substantial iron brackets built into the wall of the building, and it passes out through circular openings protected by overhanging eaves.

The tail-race is 100 feet wide at its mouth, and has a minimum depth of 3 feet. It was formed by excavating the silt and sand underlying the flat on which the power house stands, a coffer-dam being constructed across its lower end to prevent the entrance of the river during construction. It is protected by "riprap," by sheet piling on its south



A CROSS-SECTION OF THE DAM

THE LINE CROSSING AN ELECTRIC RAILWAY

LOWER SIDE OF DAM SHOWING WASTE GATES

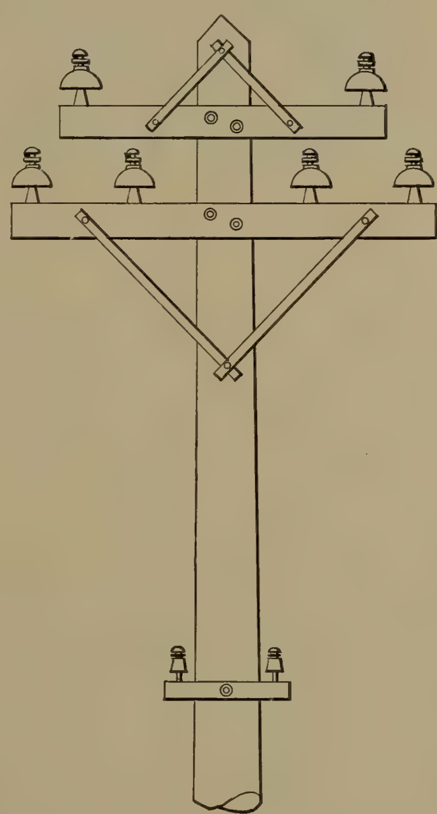
and east sides, and its bottom for some distance out from the wheel-pit is paved with 2-inch plank.

Before entering into the construction of the transmission line by which the power generated at this station is carried to St. Paul, let us stop for a moment and glance briefly at the country through which it runs. On the Wisconsin side of the St. Croix River the surface is very rough. The ground seems to consist of a series of sand dunes, varying in height and form, and covered by a thin coating of tillable earth. The roads, following along strictly on the section lines, present a succession of steeps and falls as far as the eye can reach. The St. Croix River itself flows in a deep gorge, worn out by centuries of attrition in the sand rock beneath, and the valley so formed rises by abrupt terraces, broken by innumerable deep, lateral runways, to the level country beyond. Between the river and St. Paul the country is much more even, and is well supplied with springs, which come to the surface everywhere, in many instances giving rise to lakes of considerable extent, generally lying well down below the surrounding country. In the neighbourhood of St. Paul the surface is undulating, descending by easy stages toward the Mississippi River.

This being the character of the ground over which the transmission line must run, whatever the route adopted, it was decided to make the line straight, with only slight divergencies to avoid the lakes and the more abrupt changes of level. In deciding on the grades also, due consideration was given to the advantages of a level line; but a cursory inspection of the country showing the futility of such an ideal, it was believed that the best practical result would be obtained if each pole were of such a height that its top should not be over 3 feet below a line joining the tops of the two adjacent poles. This rule was adopted in establishing gradients, the poles ranging from 28 to 50 feet in height.

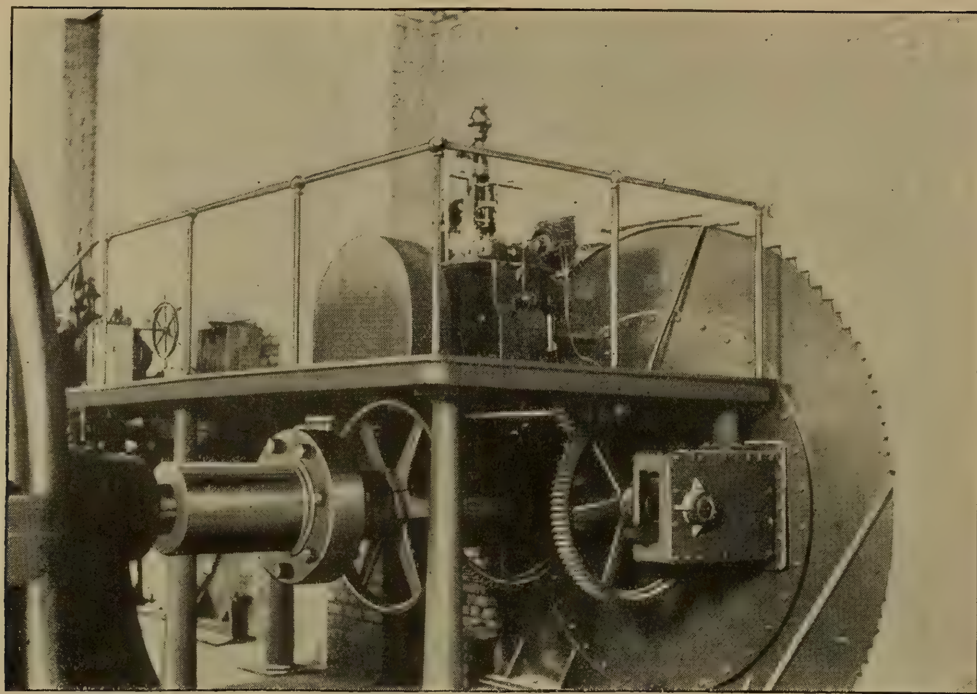
The line consists of six No. 2 B. & S. (No. 3 Birmingham gauge) medium-drawn copper wires, in two circuits of three wires each, one circuit being supported on each side of the poles in the form of an equilateral triangle with 24-inch sides. One of these circuits runs straight through without transposition, while the other is spiraled twice at equal intervals. The joints are made by giving each wire six turns about the other, the whole being soldered by dipping.

The poles are of cedar. They have 8-inch tops. Those under 35 feet in length are set 6½ feet in the ground; for the longer poles 6 inches are added to this for each additional 5 feet in the



ONE OF THE TRANSMISSION LINE POLES

length of the pole. The poles are spaced at a maximum distance of 110 feet. The cross-arms are of Oregon fir, 4 by 5 inches. They are gained 1 inch into the poles, and fastened by two half-inch bolts. Galvanised iron braces, one inch and a quarter by one-quarter inch, are bolted to both poles and cross-arms. The insulators are of glass, seven inches in diameter, and the line is tied to them by No. 5 B. & S. (No. 7 Birmingham gauge) soft-drawn copper wire.



ONE OF THE WATER-WHEEL GOVERNORS

Six feet below the lower cross-arms there is a telephone line, supported on short cross-arms bolted to the poles. This line is transposed every fourth pole throughout its entire length, and is absolutely quiet, notwithstanding the high voltage on the wires above.

In making turns, unusual precautions were taken to avoid excessive strains on the pins, fifteen degrees being the maximum deviation from a straight line allowed on a single pin. Where the radius of the bend permits, a separate pole, trimmed in the usual manner, is provided for each fifteen-degree deviation. Where the turn is abrupt, a special construction, with radial cross-arms, carries the necessary number of pins. This is illustrated in the upper view on page 254, which shows the line crossing the line of an electric railway. All poles not in a straight line are provided with pull-off guys, anchored into the ground some distance from the pole. All trimmings are heavily galvanised, the cross-arms and gains are painted with iron paint, and the butts of the poles with asphaltum.

The only engineering difficulty encountered in connection with the line was the crossing of the St. Croix River. This stream, as before stated, runs in a deep gorge, about 1500 feet wide at its narrowest place. Its bottom is of sand, which extends to a considerable depth, and necessitates the use of pile foundations for bridge piers, while its fluctuations in the winter months, when covered with ice, are fatal to all structures less substantial than masonry.

When the question first came up in the summer of 1899, a number of surveys were made by the writer, and soundings were taken at various points along the river. Of the plans presented, only those involving costly supports in the river itself seemed worthy of consideration. The method finally adopted, that of utilising the St. Croix viaduct of the Wisconsin Central Railway, commended itself for its simplicity. Among its advantages are the high level at which the crossing is made, without the swaying incident to supports from below; the opportunity for short spans; and easy access for inspection and repair.

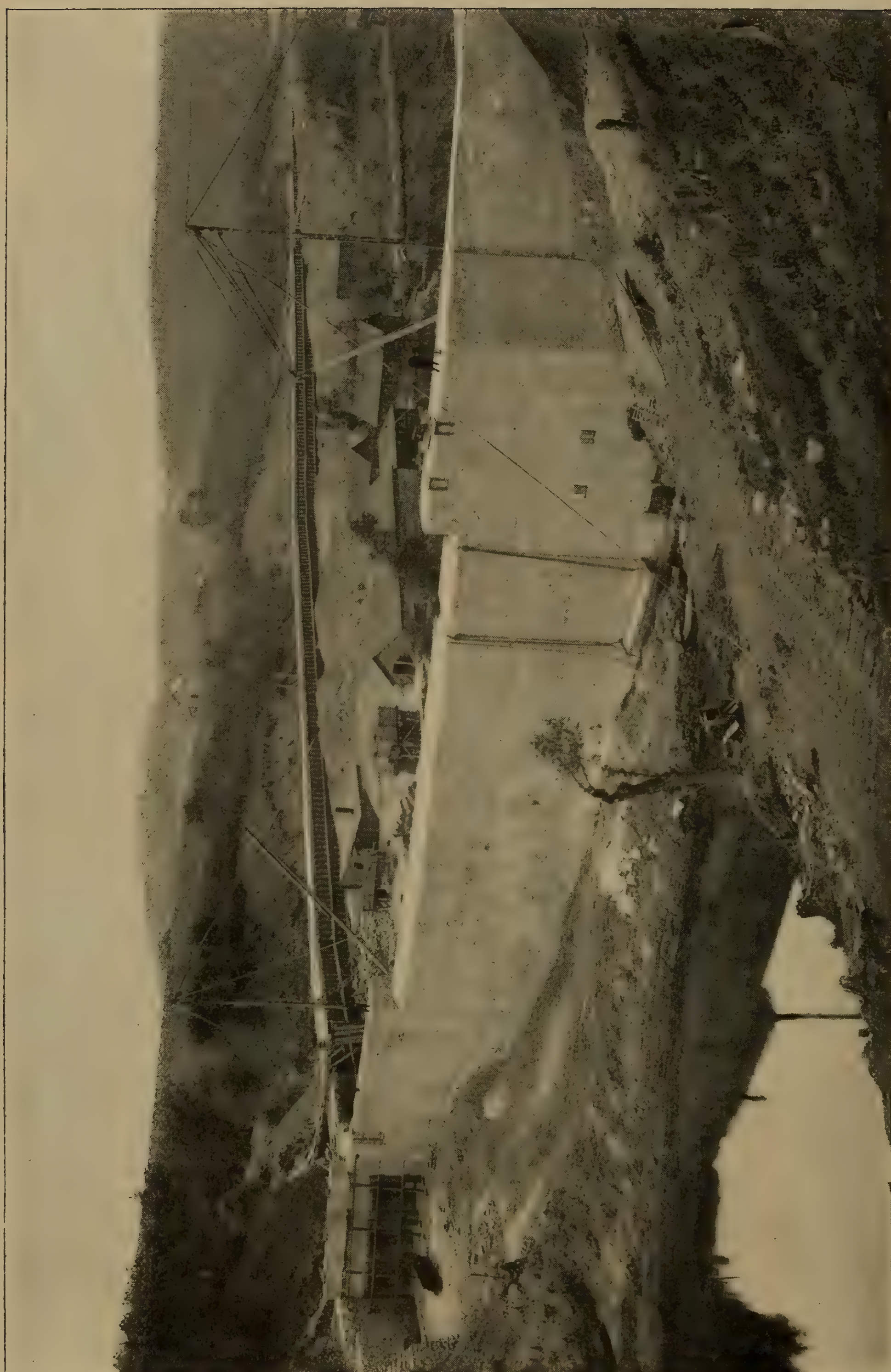
The bridge is about 2300 feet long, and the track is 82 feet above the river at low water. The line is carried by oak timbers, 8 inches square, spaced 50 feet apart, and projecting 16 feet out

from the bridge structure, at the level of the track. The wires are supported at the outer ends of these beams, on standard pins and insulators spaced 18 inches apart, the inner wire being 8 feet from the bridge. Both circuits are transposed three times in crossing the structure.

The overhead transmission line comes to an end at a second lightning arrester station near the eastern limits of St. Paul, and from that point the current is carried underground by cable three miles further to the distributing station. The cables are two in number, one insulated by rubber and the other with prepared paper, each of sufficient capacity to carry the entire load, the intention being to have a spare cable in case of accident. The cables are carried in four-hole, vitrified conduit, laid in concrete, and conforming generally to the grade of the streets.

In both cables there are three conductors, which are composite, each consisting of seven strands of copper wire enclosed in insulation, and having an aggregate area of 66,000 C. M. The three conductors are arranged symmetrically, laid up in jute, and surrounded by a layer of the same insulating material that is used within. The whole is then enclosed in an outer covering of lead, one-eighth of an inch thick. One of the cables, made by the National Conduit and Cable Company, of New York, has for its insulating material paper treated by a special process. Each conductor has a covering nine-thirty-seconds inch thick, the outer jacket being one-fourth inch thick. The other cable uses a 35 per cent. compound of Para rubber, seven-thirty-seconds inch thick about each conductor, and an outer covering five-thirty-seconds inch thick. A cross-section of the rubber cable is given on page 259. Both cables were tested

THE DAM SEEN FROM BELOW



ANOTHER VIEW OF THE DAM SHOWING THE ENTRANCE TO THE FLUME

to 40,000 volts before they were drawn in. The resistance of each conductor between the generating station and St. Paul is 22.85 ohms, and the drop in voltage, for 3000 KW with a 90 per cent. power factor, is 7.7 per cent., the initial voltage being 25,000, and both lines being operated in parallel.

The sub-station at St. Paul is a brick structure, 50 by 70 ft., set well back from the street. Entering through a large door and passing through a short hallway, the visitor comes at once into the main room, a lofty apartment containing the six rotary converters and the two switch-boards by which the current is directed to all parts of the city. A hatchway at the far end leads to the cellar, where the 25,000-volt current, entering through a tunnel from the street, is divided up and directed to the step-down transformers, ranged in a row along the wall. At the left of the entrance, and opening out of the main hall, is a room designed for the future installation of storage batteries, while a winding stairway in the opposite corner of the same hallway leads down to the lavatories and furnace room. A ground plan of the station appears on page 251.

All the wires leading to, and coming from, the building pass through the tunnel mentioned, which connects with the conduit system under the street surface. Each of the six conductors from Apple River passes, on entering, directly to a high-voltage bus-bar, from which leads are taken to a series of twenty-four three-break, single-pole switches, breaking under oil, which control the circuits to the various sets of transformers. These switches are set, each in a separate brick vault, and must be closed by hand from the cellar, while they are opened electrically by a device controlled from the main switch-board above.

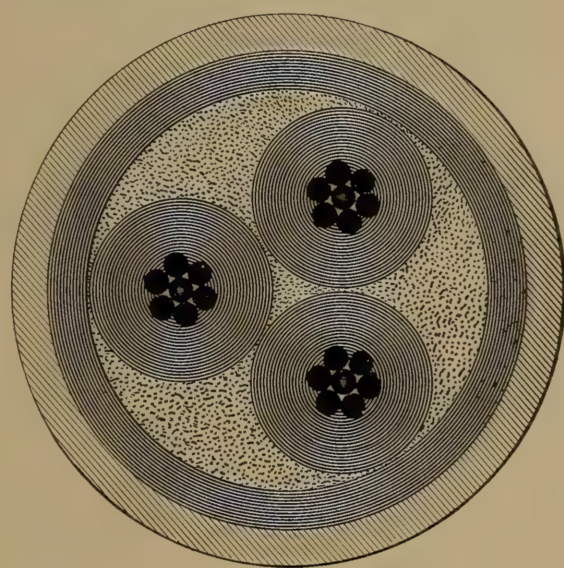
The ten step-down transformers are oil-cooled, and are divided as follows:—

Two banks of three transformers, three-phase to six-phase, 22,500 volts to 78 volts, each transformer having a capacity of 300 KW.

Two banks of two transformers, three-phase to two-phase, 22,500 volts to 2100 volts, each transformer having a capacity of 200 KW.

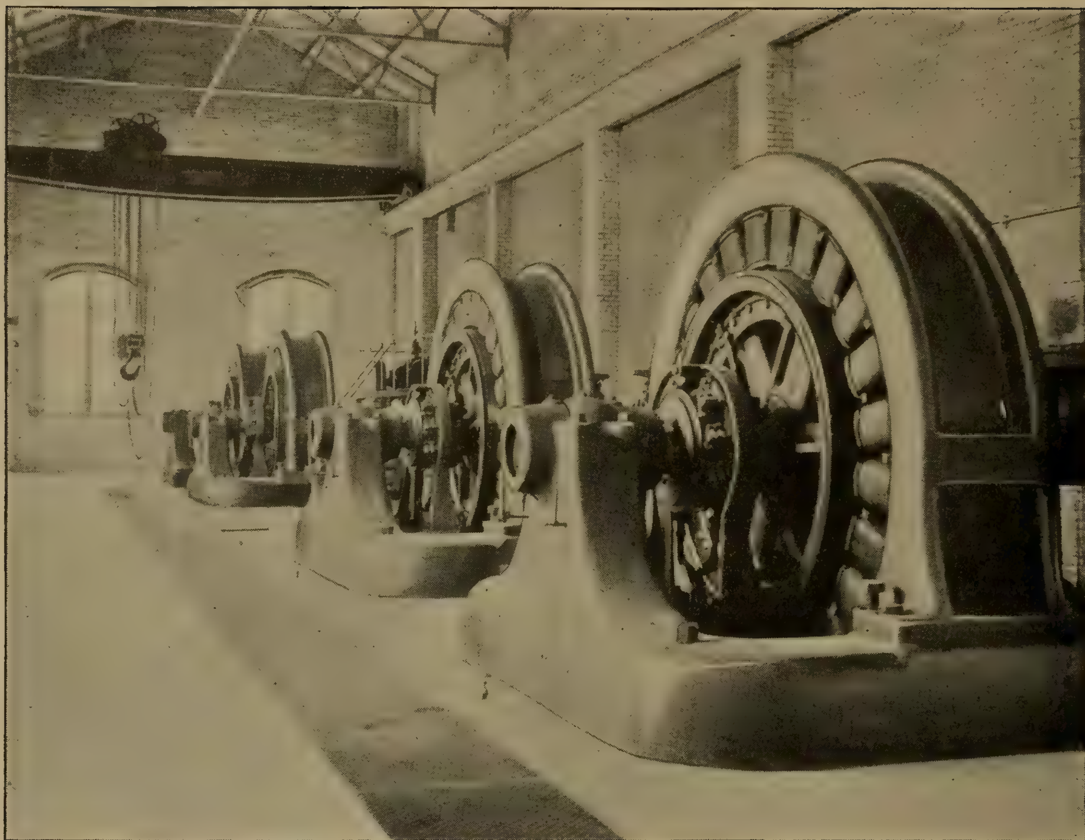
The first two banks have each a single high-tension coil and two separate and distinct low-tension coils, and are operated in conjunction with the six six-phase rotary converters, delivering direct current at 125 volts. The other two banks supply the alternating current for distribution through the city.

The six-phase rotary converters were adopted to secure a reduction of copper losses in the armatures, with corresponding reduction in temperature, and credit is due to Mr. F. O. Blackwell and other engineers of the General Electric Company, of New York, for their conception. They are operated in pairs, and supply current for the Edison three-wire system throughout the city. The potential of seventy-eight volts given may be varied seven volts up or down by a series of inductor regulators shown in the ground plan on page 251 behind the alternating-current switch-board. There is one of these regulators for each converter.



ONE OF THE JACKETED 25,000-VOLT RUBBER CABLES USED ON THE UNDERGROUND SECTION OF THE TRANSMISSION LINE

The secondary windings of the 200-KW transformers are divided, and leads are taken from each section to a quick-break multipoint switch on the outside of the case. By advancing this switch



THE FOUR ALTERNATORS IN THE POWER HOUSE

from point to point, the secondary is thrown into circuit a section at a time, and the potential is correspondingly increased, in steps of 21 volts, from 2100 to 2700. In operating the station, the potential on the high-voltage bus-bars is maintained at 22,500 volts, and the voltage of the distributing circuits is adjusted by the devices above described.

The alternating-current switch-board extends along the north wall of the building on the main floor. It has fifteen panels. Commencing at the east end of the board, the first panel contains a single-pole, double-throw switch, a starting rheostat switch, and an automatic circuit-breaker, used in starting up the rotary converters on the Edison direct current. In addition it has three multipoint, volt-meter switches. Two of these connect with the alternating-current volt-meters, hinged at the centre of the board, and by their aid the potential of any of the alternating-current feeders, or of the alternating current end of the rotary converters, may be determined. The other one is connected to the direct-current volt-meters on brackets above, and permits a reading from the Edison feeders or the direct-current end of the converters.

Next come six panels for the seventy-eight-volt, alternating-current end of the rotaries. These panels have an alternating-current ammeter, an indicating watt-meter, and switches for the six-phase circuits. They also have a two-pole, double-throw field switch, the field rheostat handle, a direct-current starting switch, the usual synchronising plug and lamp, and a switch for the motor for the inductor regulators behind the board.

The five panels following control ten single-phase, alternating-current lighting circuits. Each of these panels has an ammeter, an automatic circuit-breaker, and an oil switch in series with a system of plug switches, so arranged that any feeder may be connected with any pair of the eight bus-bars.

Then comes a panel which controls the power-distributing, two-phase circuit; then a panel connecting with each of the two sets of the 200 KW trans-

formers; and finally a panel connecting with one of the company's steam generating plants, and through which current is ordinarily sent to that station for distribution. In case of accident, the operation may be reversed, and the steam station made to supply current through this switch-board.

The three-wire, direct-current switchboard occupies the east side of the room, and has eight panels, five for the feeders of the Edison system, and the remaining three for the direct-current end of the converters, each panel controlling the output of a pair of rotaries operating together. On each of the feeder panels are installed four single-pole, four-throw switches, specially designed for this board by Mr. H. J. Gille, and arranged to permit any feeder to be thrown on any of four sets of bus-bars with which the board is equipped. Each set of bus-bars may be operated at a different voltage, one from each of the three pairs of converters, and the fourth from the storage battery to be installed later, thus giving great flexibility in the potential of distribution.

The static transformers and converters were furnished by the General Electric Company, and the switch-boards and high-tension switches by the General Incandescent Arc Light Company, of New York.

The complete plans for the plant were prepared under the direction of Mr. Robert N. King, Mr. F. O. Blackwell, of the General Electric Company, rendering valuable assistance in connection with the electrical apparatus. Mr. H. L. Doherty, president of the Denver Electric Light Company, is also entitled to credit in connection with the work. Messrs. H. J. Gille, electrical superintendent, and Fred R. Cutcheon, engineer, of the St. Paul Gas Company, had much to do with the design of the substation; and Mr. W. S. Morton, of St. Paul, had charge of matters connected with the right of way and pole line.

The St. Croix Power Company was incorporated under the laws of Wisconsin. Mr. A. P. Lathrop is its president and F. W. M. Cutcheon its general counsel; and Messrs. L. W. Rundlett, Henry Floy, and J. L. Harper were employed by them to see that the contract for the work of construction was faithfully carried out.

CRANES AT THE PARIS EXHIBITION

By Joseph Horner

THE two cranes which attracted most attention at the late Paris Exhibition were the 25-ton Goliath, of Carl Flohr, a Berlin firm, and the 30-ton Titan, of Jules le Blanc, a Parisian firm. Both were designed for service in Machinery Hall for the work of erection and that of dismantling the machinery. The Flohr crane was illustrated and described in the October, 1900, number of this magazine, and will not, therefore, be further referred to here. The Le Blanc Titan was of a type primarily designed for loading and unloading vessels, the firm having built a similar one for the port of Bremerhaven. The work of the Exhibition crane consisted in taking the machinery from the railway trucks at the gates of the building, carrying them up the building,—a length of 377 feet,—and depositing them to the right and left over a width of about 72 feet. The superstructure swung around a complete circle, and was so balanced that the centre of gravity always was within the roller path; yet the stability was such that 50 tons could be lifted at maximum radius without overturning the crane.

There were many interesting details about this Titan, in which it differed from other Titan cranes. Some of these details are illustrated by the two sectional views given on page 264. The general design is well shown in the cut on the next page. Of course, the crane was driven electrically, like nearly all the other cranes at Paris. The current,—of 240 volts in this instance,—was taken from two overhead copper wires by means of a trolley pole above the crab, suitably pivoted, details of which are shown, whence it was brought down to the cage, to actuate the motors, of which there are two. The travelling motor, of 20 H. P., is fixed to the platform shown in the illustration, and current is conveyed to it through the central pivot of the crane, about half way up in the tower. Movement is transmitted thence by means of inclined shafts situated midway between the travelling wheels. These are not seen, being hidden behind the inclined legs, the slope of which they follow. The detail of the transmission at the lower end is seen in one of the cuts on page 264, *A* being the end of a shaft stepped into bearings of phosphor bronez. The movement is transmitted and speed reduced by means of two pairs of toothed gears,—a pair of bevels, *B* and *C*, and a pair of spurs, *D* and *E*, the first spur being keyed on the same spindle as the driven bevel *C*. A strong sprocket wheel, *F*, is bolted next the face of the second or driven spur, and the Titan is travelled by the engagement of this sprocket with pins, *G*, which are bolted at exact pitched centres of 150 mm. (5⅞ inches) between the double rails, *a a*, of the track. The rail centres are 160 mm. (6¼ inches) apart, giving a broad track for the wheels. There are two pairs of wheels under each leg, made of two dished discs of steel, ribbed, and bolted together, the axles of which run in bearings of phosphor bronze. The minimum speed of travelling is about 13½ feet a minute with the full load of 30 tons; the maximum speed is about 66 feet. Unloaded, the crane will travel at 78 feet per minute. The varying speed is effected through the motor, and it can be slackened or stopped without shock, so that heavy loads can be delicately handled.

The movements of lifting, racking the trolley, and slewing the crane are all derived from a 16-H. P. motor on the upper platform of the superstructure. A central shaft operates all these move-

A 30-TON TITAN CRANE BUILT BY JULES LE BLANC, PARIS

ments by means of belts, toothed wheels, and chains as follows:—Each separate movement is transmitted in the first place by its own belt,—straight, or crossed, from the main shaft. The shafts for racking and turning are behind the main one, the lifting shaft in front, and below.

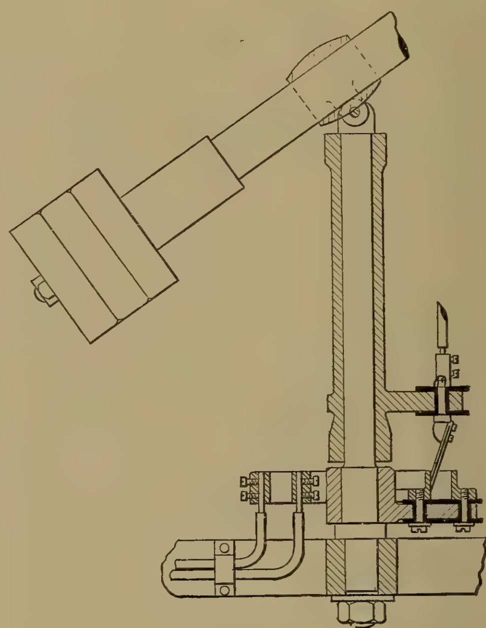
The method of driving by belts is one which is now regarded with disfavour in Great Britain and the United States, the objection being that of slip on such short drives, and it is being gradually abandoned in consequence. The makers of this Titan give preference to belts, on the ground that they work without jar or noise, and will slip under too heavy or sudden stress, so avoiding accident. But, in fact, when three separate motions are derived from a single motor, belts are scarcely avoidable if bevel and worm gears are to be dispensed with, as they are in this example, in which spur gears alone are used. The motor, of course, in such a case runs at a constant speed, and the rates are changed by gears. The rates of the three movements are as follows:—The speed of rotation is about 13 feet a minute; that of the crab, trolley, or jenny is about 38 feet. The maximum lifting speed for 30 tons is 11 feet. The maximum lifting speed for a 10-ton load is about 6 feet, and for lowering, a little over 8 feet.

The lifting is done by pitch chain, 82 feet long, the slack being wound round a narrow drum of sheet iron, about 6

feet in diameter, turned by a belt. The same belt acts as a brake in returning, preventing the chain from unrolling more rapidly than is necessary. The sag of the chain is carried on two rollers, which open out to permit the trolley to pass. The range of the lifting hook is 41 feet vertically, with a racking movement of about 28 feet. There are two brakes on the lifting shaft, one of which throws the belts off, the other stops the chain.

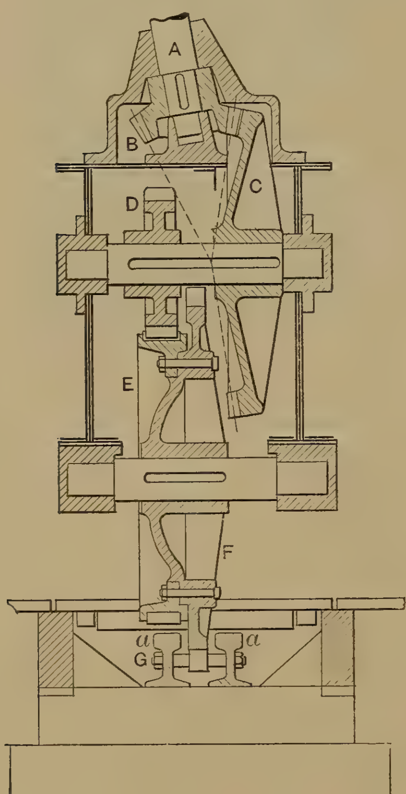
The general design of the Titan framing is well shown in the illustration on page 263. The travelling portion is built of box girders; the uprights, about 33 feet long, are inclined at an angle in both directions, and united with the bottom sills that carry the travelling gears and with a frame at the top, and also to a platform stage at a height of about 16 feet from the ground, between which and the top frame diagonal counter-braces are riveted. The distance between the centres of the rails is about 20 feet; the length of wheel base is 23 feet, which affords an ample base for the tall structure, the height of which to the platform of the revolving jib is somewhat over 46 feet.

The superstructure is connected with the travelling platform by a forged steel



JOINTING OF TROLLEY PIVOT OF THE LE BLANC CRANE

pivot, 8⅝ inches in diameter, with a small hole through the centre for the passage of the electric cable. The weight of the superstructure is taken on a steel roller path, built in six segments, and receiving the pressure communicated through forty-eight rollers, the pins of which are carried in two concentric rings. The total load of the superstructure on the rollers is 120 tons, but by means of compensating levers the load at front and back is distributed over four rollers at once, so that the load on a single roller is only 30 tons. The roller path is about 15 feet in diameter, its height from the ground is 13 feet, and the total weight on the ground rails is 130 tons.



DRIVING GEARS FOR TRAVELLING THE LE BLANC CRANE

A well-designed gantry crane, shown by the Fives-Lille Company, of Fives-Lille, Belgium, and Paris, on the Quay d'Orsay, near the Creusot Pavilion, was also used in the service of the Exhibition. (See page 274). Its power is about 24½ cwt. The lifting and rotating are

effected by electric motors; the travelling is by hand gear, the necessity of travelling occurring comparatively seldom. The crane was built with a "portal," or opening, of a size to admit the waggons of the French railway companies, clearing about 10 feet in height. The gauge is 13 feet. Lifting and slewing are effected by independent, continuous-current motors, at 220 volts. The first is of from 28 to 30 H. P., and lifts the load of 1250 kilos at a speed of about 4 feet per second. The 4 H. P. slewing motor revolves the crane through a half revolution in thirty seconds. The radius of the jib is nearly 38 feet from the centre of the crane, but the effective radius from the edge of the quay is slightly over 24 feet.

Current is brought by flexible conductors or cables rolled on a holding drum alongside the platform of the gantry. Collecting brushes take it off on two poles in the central pivot. The switches, resistances, and ampère and volt metres are all enclosed in a house within easy reach of the driver. The motors, though outside, are encased, to be weather-proof. The brake is automatic, its solenoid being in circuit with the lifting motor, so that when the current goes off the brake goes on, and off when lifting commences.

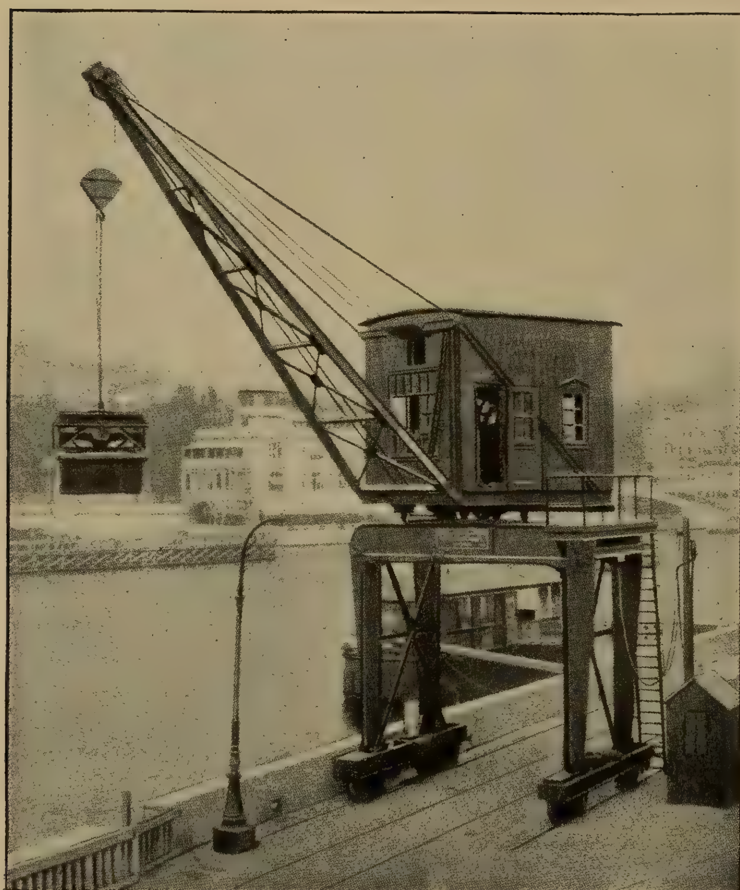
The crane is of the balance type, the counterweight being high up, out of the way. The superstructure runs on half a dozen rollers. Blocking of the truck during lifting is effected by means of four jack-screws at the corners, the heads of which rest on the track. Tipping of the superstructure is prevented by clips, which grip the steel curb ring, flanged for this purpose. In any radial position these clips are, therefore, ready to hold and counteract any tipping tendency. Cast iron enters but slightly into the construction of this crane, the whole of the main framings of gantry, superstructure, including roller rings, and jib being plated. The chain drum is grooved, and its wheel has double helical teeth.

The gantry or portal crane of Messrs. Mohr & Federhaff, of Mannheim, Germany, of which an illustration appears on the next page, was exhibited on the Quay d'Orsay, close by the Pont de Jena, together with a grab which it was designed to operate. Like nearly all the power cranes in the Exhibition, it was driven by electricity, with an alternating current of 200 volts and 50 periods a second. The motors used are one of 23 H. P., making 570 revolutions per minute for lifting, and one of 4½ H. P., making 940 revolutions, for the movements of rotation and travel. The current was conducted by three underground cables, enclosed in a protecting conduit. The arms by which contact is made are protected by levers in front and rear, so that if an obstacle is encountered, one of the levers is pushed against a tripolar interrupter, and the crane is stopped. The lifting motor is carried on the footplate at the rear of the crane, with its axis parallel with the shafts of the lifting gears, so that no worm gears are used for transmission. Wire rope is used for lifting, winding around a grooved drum. Lowering is done by the brake, the drum being disconnected with the first motion shaft during descent. The pinion which gears with the drum wheel is fixed to the brake disc, and turns loosely on the shaft by means of a bronze sleeve, while the brake disc is keyed to the shaft.

There is an ingenious arrangement by which the hook is prevented from striking the jib pulley at the termination of its ascent, thus:—By means of a pitch chain the movement of the drum is transmitted to a shaft having a stop screw. A disc is screwed on the shaft, and a second disc, fixed on a pivot, slides over the shaft, following the stop screw. The two discs have catches which meet at the moment the load has attained its maximum height. The pivoted disc is then pulled over, and bv means of a chain pulls the starting lever to the neutral position.

The lifting power of the crane on a single chain is 1500 kilos (29½ cwt.), and with the return block, 3000 kilos (59 cwt.). The hook will lift over 65 feet. The rate of lifting is about 2½ feet a second on single chain, and 1¼ feet a second with the snatch block

in use. The slewing is effected through worm gearing, the worm being double-threaded, of hardened steel, on a prolongation of the motor shaft. Its end thrust is taken by ball bearings, and the gear runs in oil. The motion is transmitted to a pinion driving the curb ring, which slews the crane on four rollers. Cast steel is used for both ring and rollers. The radius of the crane is about 46 feet, and the speed of rotation at the hook is about 5 feet per second. The travelling is done from the slewing motor



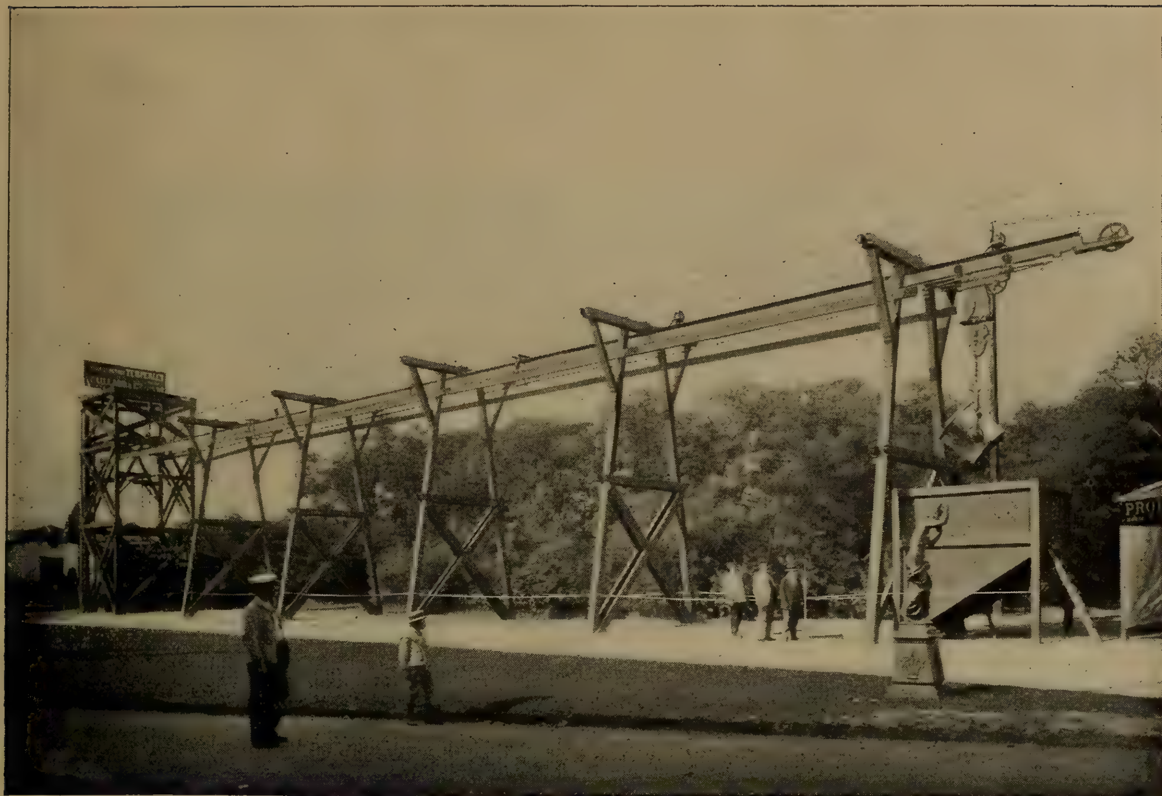
GANTRY CRANE BUILT BY MESSRS. MOHR & FEDERHAFF, MANNHEIM, GERMANY

through another set of gear. A shaft comes down through the centre of the crane, and drives, through mitre wheels, a horizontal shaft running alongside the bridge part of the portal framing, whence vertical shafts are driven through mitre gears to the driving shafts and wheels below. The driving is imparted to two wheels on opposite legs of the crane, the other two being simply trailing wheels. The rate of travel is about 7 inches a second.

The grab is opened and closed by means of a second wire rope, which operates a chain round its barrel, and by which the action of opening and closing is effected at all heights. The drum which operates the grab is moved by a return block, so that by lifting the load, the wire rope is automatically wound round the drum. The two wire ropes for lifting and grabbing, respectively, pass over pulleys which lie adjacent on the same spindle at the top.

In the electrical details, the operating levers are so arranged that the lifting can be controlled by the right hand, and the rotation and travelling by the left. A third lever is used for working the grab or excavator. The rheostat for lifting has the carbon contacts arranged in a circle on a plate of marble on the box. They are divided into three groups, corresponding to the number of phases of current. Three copper rollers move simultaneously on the three carbon groups to connect the current. These three groups are connected with resistance spools in the box, each phase having its separate resistance. The rheostat for rotation and travel is constructed on the same principle. The movements of lifting and rotation correspond with the proper direction of the movement of the lever for each, so that an absent-minded man could scarcely make a mistake. Cranes of this type are great favourites on the Continent. They abound along the quays of rivers and harbours, and are generally driven electrically. In Great Britain the best installation is probably that at Southampton Docks, also motor-driven.

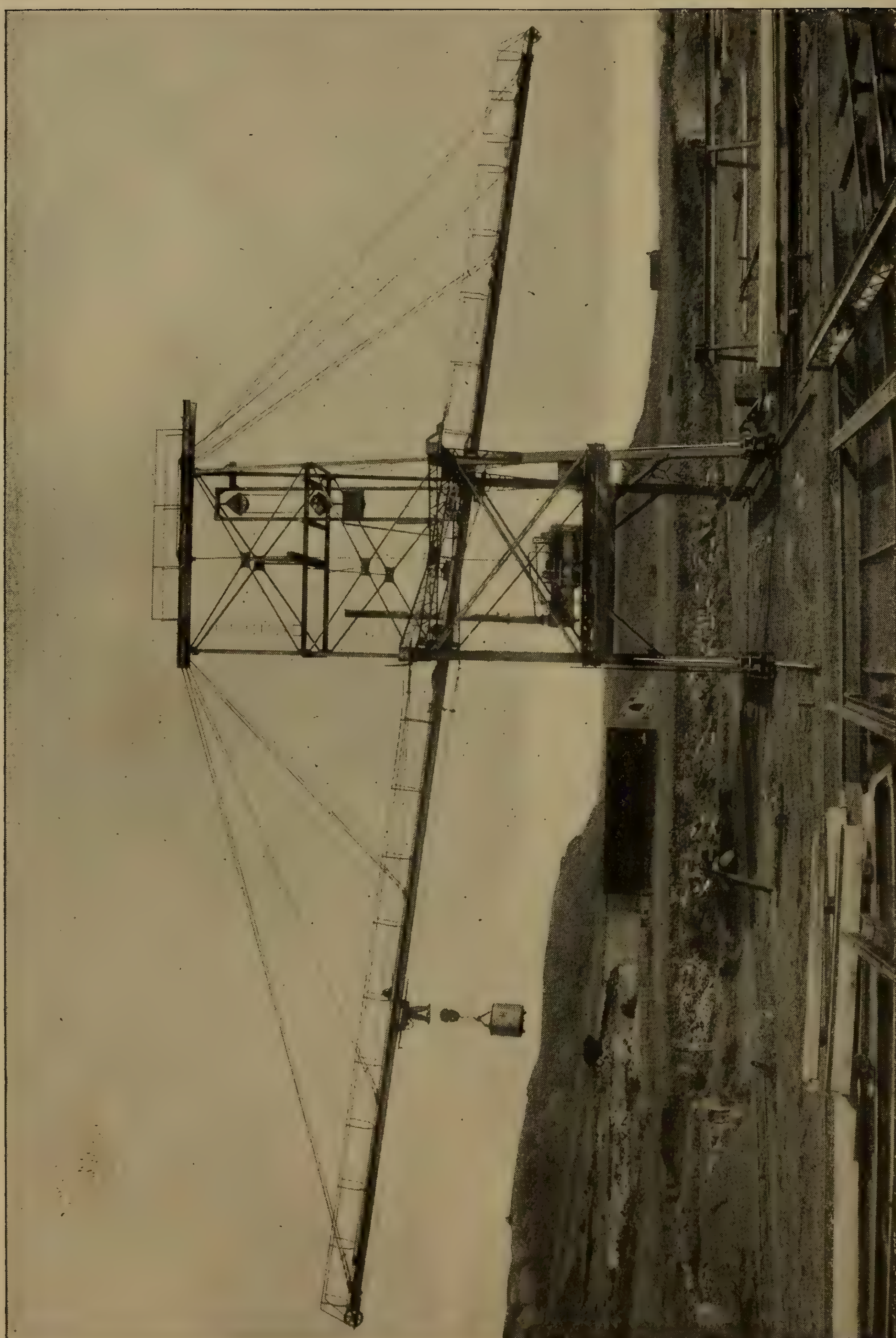
The Temperley Transporter Company, of London, showed more enter-



THE TEMPERLEY TRANSPORTER AT VINCENNES

prise at the Exhibition than any other British crane-building firm. They erected and put in operation a transporter 164 feet long at Vincennes, and a large working model of a 30-cwt. machine in the Champ de Mars, a representative being in constant attendance at each place. As a clever piece of automatic mechanism, and for rapid handling of light loads, the transporter stands unrivalled, while its adaptabilities render it suitable for a very wide range of tasks.

The 30-cwt. machine, of which a model was shown, and of which an illustration is given on page 268, has a lifting speed of 300 feet per minute, and carries its load along at the rate of 600 feet per minute. Differences of gauge and length commanded are, of course, made to suit customers. In this instance the arm extends 45 feet over the water side, and 70 feet on the land side, which, with a gauge of 20 feet, makes a total length of 135 feet. Its capacity is 50 tons an hour. The model at Paris was to a scale of one inch to the foot, and was complete in every detail, including the automatic levers and catches in the "bell" or "hood," the action of which is a detail of never-ceasing interest. The transporter at Vincennes carried gravel in its skip from one end to the other of its length, and dumped it automatically, the operation of lifting, transporting, and depositing occupying but a minute. The methods of operation of these cranes are known to many, but it may be well, nevertheless, to give a brief account of them. Although the overhang of the arm is great, and the movements rapid, the structure is stable on its tower without any blocking, due to the spreading legs and the broad gauge. The arm over the vessel, say, which is to be loaded or unloaded, is hinged to be raised clear of the work. A winch on the platform,—motor or steam-driven, — controls a wire rope passing from the drum over guide pulleys, the last of which is at the end of the jib. It is connected at its other end to the trolley carriage, passing thence over a guide pulley. The chief peculiarity, perhaps, of the crane is that, apart from the winch, there are no toothed gears, one result of which is a



A 30-CWT. TEMPERLEY TRANSPORTER, OF WHICH A MODEL WAS EXHIBITED AT PARIS

smooth and quiet action at high speeds, the only noise being that of the trolley, or traveller, running along the beam. Everything is done to facilitate speed of working. The engines do not reverse, but the hoisting drum runs loose, and is put into action for lifting by means of a friction cone. The engines being on a tall platform in the tower, the attendant has a clear view of his work.

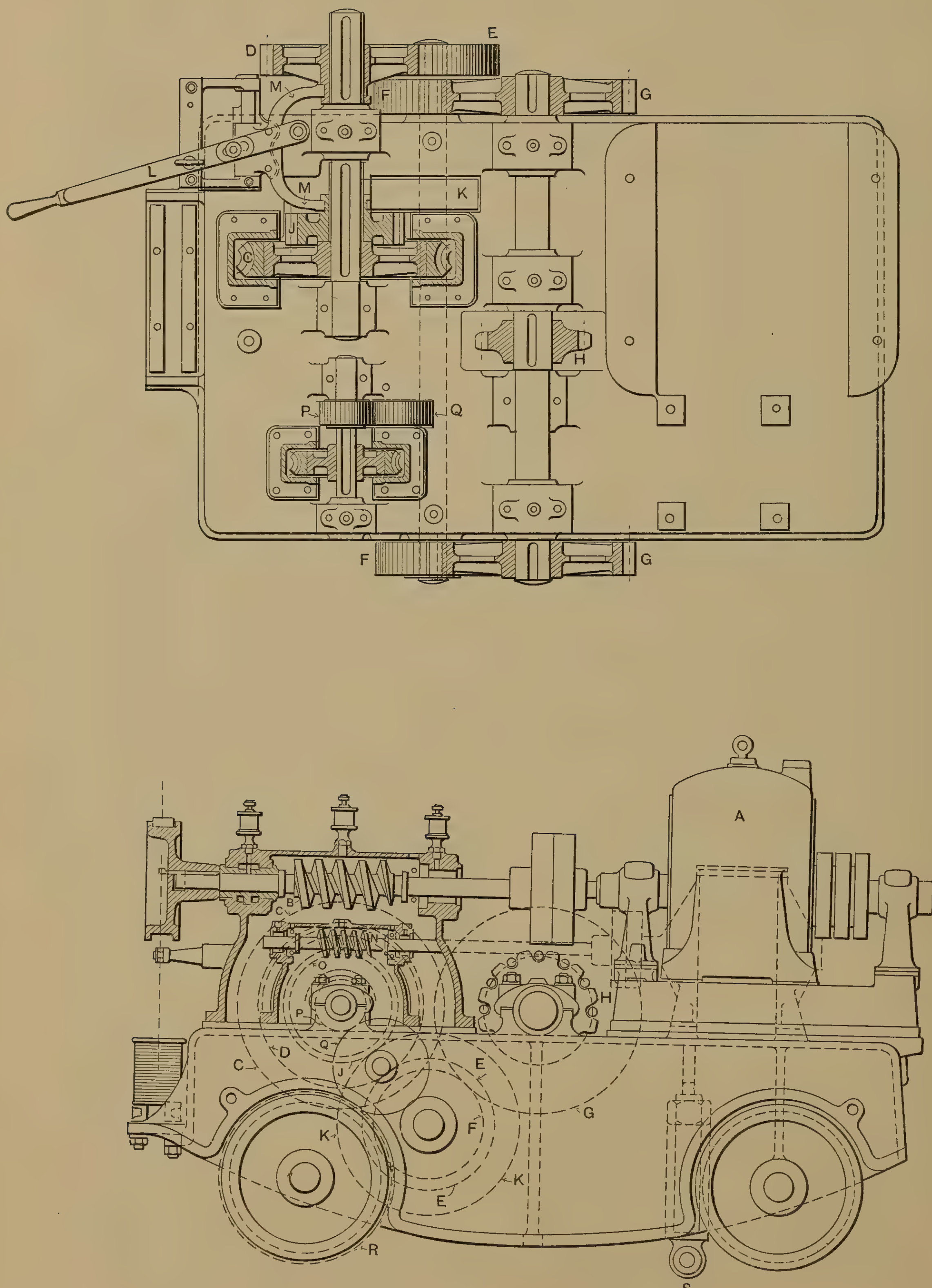
Note may be made of two important facts, one being the automatic action of the trolley; the other, that of the skip. In the first, the act of raising the "fall," or snatch block, to its highest point, that is, into the "bell," has two results. First, as it enters the bell, the load is taken at once by pivoted hooks, and the rope is immediately relieved of further strain; and secondly, it releases the trolley from its grip upon the beam, down which it is free to run as the hauling rope is paid out. When the trolley has been traversed to the required distance, the hoisting drum is thrown out of action, and the trolley runs down and engages with a stop which sets certain levers in motion, releases the return block from the bell, and locks the trolley to the beam while the skip is lowered by its rope. The skip having been lowered to the level at which it is desired to tip, a reverse movement is made in the direction of lifting. This tips and discharges the contents. Then the skip rights, and locks itself, and so returns ready for refilling. The only manual operation required has to be done then by the men who refill it, consisting in moving a lever which throws the dumping mechanism out of action, so that the skip returns safely, and will not tip until transported, lowered, and lifted.

The Oerlikon Works, of Zurich, had two electric crabs, or trolleys of 10 and 30 tons capacity, respectively, at their stand; not on gantries, for which there would not have been room, but on temporary girders. Each was of the three-motor, three-phase type, which is standard practice with this firm, who apply and recommend single-phase motors only when a continuous current is already installed in a works. In this they are at one with the nearly universal Continental practice, the reasons for which are the greater simplicity of the three-phase motors,—the most vital parts of the mechanism,—on which the safe and regular working of a crane depends. There is also in these motors the advantage of the complete absence of collectors, the fact that they support momentary strong surcharges of current without inconvenience, and that reversal can be effected abruptly without injury to the motor. One of the Oerlikon designs is shown on page 273.

The Oerlikon trolleys have few points of resemblance with either British or American, excepting in the fitting of a separate motor for each motion. The details of design are different in nearly all respects. They have no chain drums, and the framing is of the plainest character, the sides being made parallel, whether cast as in the small trolley, or built up of joists as in the large one. There is an advantage, however, in this design, in lessening the head room necessary, for the wheel axles are about central with the framing, instead of being below it. The gears are mostly below the level of the top of the framing, so that little appears above the top edges, excepting the motors and worm-gear boxes. Cranes up to 65 tons are made with frames of plain H joists, though the necessity of introducing more gearing alters the other features of design.

There is a curious feature in the traversing gears of the crab. One of the running wheels is utilised also as a toothed wheel through which the drive is effected. In British practice, the toothed wheel which effects this function is cast separately from, or shrunk on an extension of, the running wheel of which it forms an integral portion. In the Oerlikon, and in other examples, the teeth flank the wheel tread on both sides, and the driving pinion is broad enough to bridge across both sets of teeth.

Although no labour is thrown away in useless work, and the framings are of the simplest and cheapest, yet in all essentials no pains are spared. The



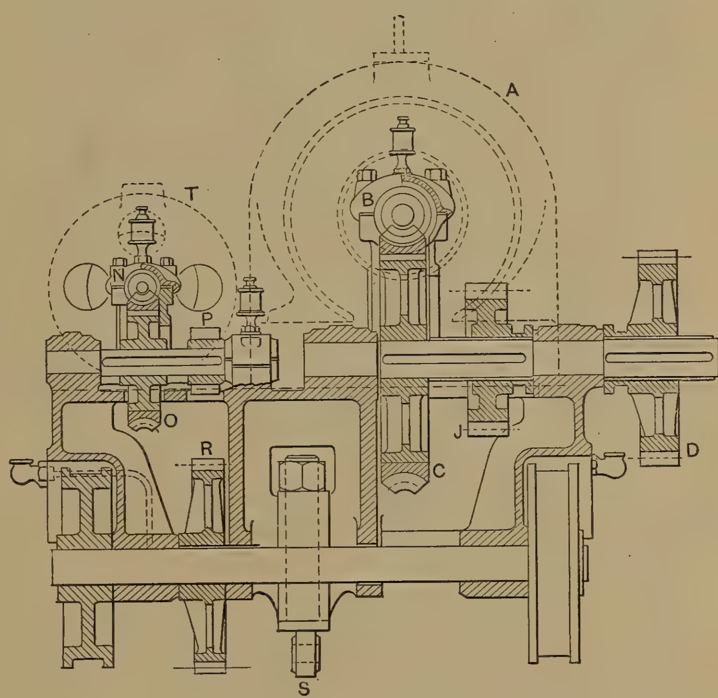
PLAN AND ELEVATION OF CRAB OF THE CRANE SHOWN BY MESSRS. GANZ & COMPANY, BUDA-PESTH

gears are cut, the worms are of hardened steel, the teeth of the worm wheels are cut on rings of phosphor bronze, and they run in a box filled with oil. The axle pressure is sustained by a ring of balls between hardened discs, the thrust being always in one direction only. The traversing worm has hardened ball thrusts at each end, the movement being in both directions. The hook swivels on ball bearings. The shafts of worms are lubricated by means of the ring oiling device. The running wheels are of cast steel. As there is no drum on these crabs, the slack of the chain is suspended from a guide in the lower part of the framing. The transmission from the worm gear to the chain sprocket is through spur gears. The brake automatically blocks the load when the motor ceases working, and holds it in suspension. The release of the brake when the motor is put out of circuit is effected by means of a cable and pedal from the floor of the cage.

In the 10-ton trolley, a 12-H. P. motor actuates the lift, and a 1½ H. P. the cross traverse of the crab. The speed of lift is about 13 feet a minute, while that of transverse movement is about 33 feet. The 30-ton trolley has a lifting motor of 18 H. P., and one of 4 H. P. for the transverse movement. The lifting speed is about 4½ feet a minute, and the transverse, 26 feet. The Oerlikon firm, it may be mentioned here, has installed over 300 travelling cranes.

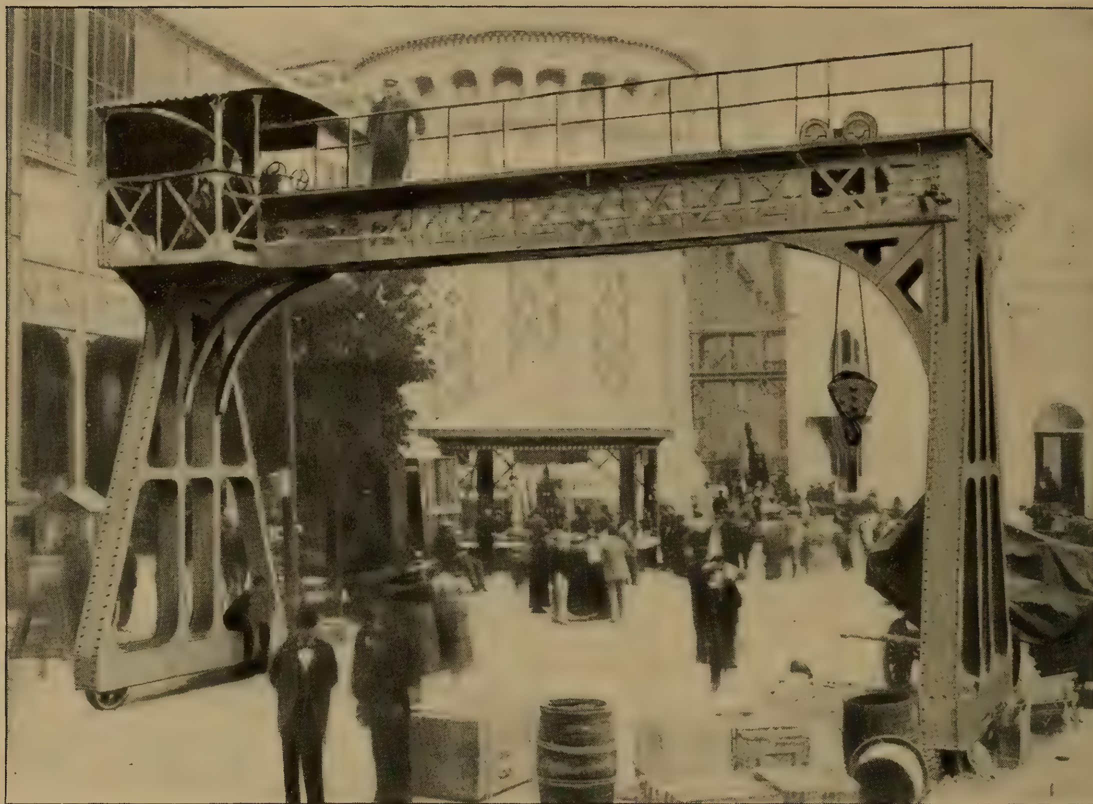
The electric overhead travelling crane of Messrs. Ganz & Company, of Buda-Pesth, spanned the electric exhibit of this firm. The gantries were carried upon steel pillars, built of plate and lattice work, and connected at the top with light, braced arched girders. The gantry girders themselves were single-webbed, with broad feet, well bracketed, and were trussed with angle bars connected to an arched bottom chord. This, of course, was a structure specially designed for Exhibition exigencies, which would be varied in any way to suit workshops. The principal interest was in the crabs, of which there were two, and in the bridge on which they were carried.

The bridge, in one respect, embodies a practice that is growing in favour, and which is a result of the higher speeds at which travelling is done now by comparison with those of pre-electric days. The single-webbed girder, unbraced laterally, and ill suited to resist the flank stresses which are developed at high speeds, is replaced by a webbed girder



END VIEW AND SECTION

braced by a flanking parallel lattice girder, set at a distance away, but connected thereto by means of light horizontal bracing of angle section. The space which separates the two is then covered over and forms the platform, and beneath this, on one side, the travelling motor and the gears through which the longitudinal travelling shaft is driven are placed, and also the shaft itself, all being snugly protected. This design effects a considerable saving in weight over that of a heavy box girder. It requires no extra brackets for the platform, is absolutely rigid under the



SEVEN-TON ELECTRIC GOLIATH CRANE BUILT BY M. M. GUSTIN FILS, DEVILLE, FRANCE

highest speeds, and avoids that standing out of shaft bearings and of motor which is objectionable on some of the older designs. The end cradles, or end girders, are boxed up with plate and angle, completely covering the travelling wheels, and are riveted to the bridge girders with angles. The wheel bearings are fitted with bosses into holes in the web plates of the end girders, and are bolted on their faces, in the manner adopted in good work. An 8 H. P. motor is used for travelling, and the driving is through gears at each end of the bridge.

The two crabs, or trolleys, between which the load of 20 tons is divided, are very snugly designed, so that their length is reduced to a minimum. The side frames are of cast iron, arched to clear the running wheels, which are carried inwards, and covered over by the frames. The gears are encased, according to a practice which is very common also on Continental machine tools. The motors for lifting and traversing,—of the three-phase class,—are carried upon the crabs, the first being of 12 H. P., and the second of 3 H. P. The current is used at 220 volts. Transmission is through worm and spur gears only, the worm being single-threaded. The general arrangements are shown in elevation, in part sectional plan, and in cross-section on pages 270 and 271.

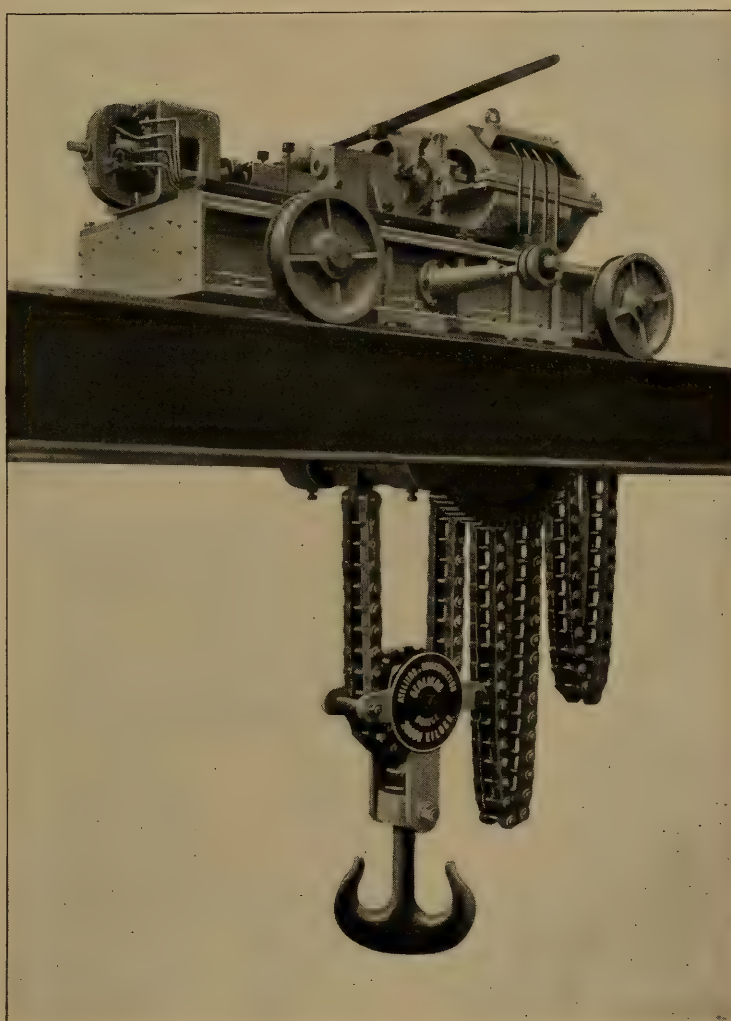
The lifting motor *A*, bolted on the facing seen in the plan, drives the worm *B* and wheel *C*. The worm-wheel shaft is splined to permit of the simultaneous operation of two wheels *D* and *J*, of different sizes, through the lever *L*, common to both, which moves the horns *M M*, engaging with clutches cast with the wheel. These connect to different trains of gears for fast and slow lifting. Tracing them out, wheel *D* drives *E* on the same shaft as wheel *F*, which, engaging with *G*, drives the sprocket wheel *H* for lifting at a quick speed. This is the arrangement shown in gear in the figures. Wheels *F* and *G* are duplicated on opposite sides of the crab. For slow lifting, wheel *J* is slid into engagement with *K*, and wheel *F*. on the same shaft, gears with *G* on the sprocket shaft. The traversing of

the crab is from the smaller motor, seen in dotted outline at *T*, to the worm *N*, wheel *O*, and thence, at reduced speed, through the spur gears *P* and *Q*, to *R* on the driving axle. The chain passes over the sprocket wheel *H*, drops down, forms a bight round the snatch block, and, returning, is anchored to the eye *S*. On the other side of the sprocket it drops to give the slack, which forms one loose bight only, the other end being brought up and fastened to the crab framing. All the movements are operated from a cage, which contains the rheostat, fusible current breakers, etc.

Stork & Co., of Hengelo, showed an electric Goliath of 10,000 kilos (nearly 10 tons) power. Each movement had its own motor, series-wound. The lifting speed, of about 6½ feet per minute, took one of 9 H. P.; the travelling of the Goliath at a speed of about 65 feet was by a 4-H. P. motor, and the traverse of the crab at 49 feet was obtained by one of 2 H. P. The revolutions of these at the maximum rates were 800, 1000, and 1200 per minute, respectively. The general arrangements of the crane accorded with best practice, such as the interposition of flexible couplings on the motor shaft, the cut gear teeth, the worm running in an oil bath, ball bearings for worm and for hook, the bringing all the controlling levers into the cage, all handles moving in the direction which the load must follow, and other features.

A 7-ton electric Goliath, by Gustin Fils, of Deville (Ardennes), had the gear fixed at one end, the load being manipulated through a trolley traversing the bridge girders. The load was handled through friction cones, and the travelling motion through other cones, driving the horizontal shaft beside the bridge, and the vertical shaft therefrom, through mitre gears. The various motions and the brake lever were all controlled from the one end. It was a creditable example of French practice, both in regard to the operating mechanism, and also of the light, yet rigid, main framings which are built wholly of plates, bars, and sections, riveted up.

Ed. Auge, of Paris, had a 1500-kilo (29½ cwt.) electric fixed gantry crane, in which the chain ran over cupped pulleys instead of over a barrel. The motor at the rear drove from slow gear through a belt to the crane. A hand Goliath, by Rondet, Schor & Co., of Paris, was timber framed, with the small sheaves and the pocket for slack chain inside the frame, a design which



THIRTY-TON ELECTRIC CRAB OF THE CRANE BUILT BY THE OERLIKON COMPANY, ZURICH, SWITZERLAND

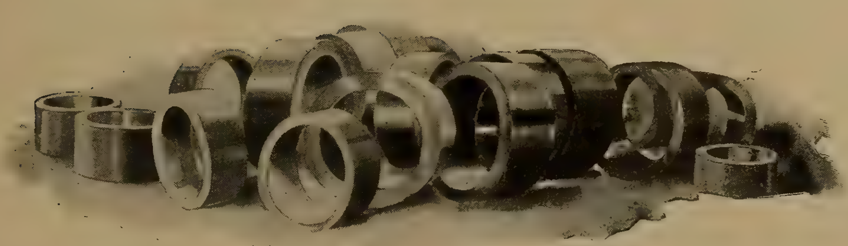
ELECTRIC GANTRY CRANE BUILT BY THE FIVES-LILLE COMPANY, FIVES-LILLE, BELGIUM

is met with continually in the smaller kinds of French hoisting tackle. The handles and gears were duplicated on both uprights. A single chain passed up from each set over its guide pulley at the top, thence over fixed guide pulleys on the trolley, with six falls (three laps of chain) to each of the snatch blocks below. The Goliath was of short span, and was fixed. Each block could lift separately, or the two in unison. The ratchet was nearly as big as the large toothed wheels.

The same firm had an electric horizontal crane, in which the motor and its details were at the rear, and so assisted to balance the load. It drove by belt to the French type of chain cup, with pocket for the loose chain. The slewing gear was in front, and was driven by belt, bevel wheels, and cones, driving to an external curb ring.

Mining winches of the double-drum type were shown by G. Pinette, of Chalon-sur-Saone, and by Fournier & Cornu, of Genelard (Saone and Loire). Some of these were of large dimensions and mostly steam driven. One, which was electrically operated, had cut gears for motor spindle, pinion, and first-motion wheel. Helical gears were employed in all the winches, small and large alike, for driving from the engine shaft to the first-motion shaft. Foot-operated band brakes were fitted according to the common practice. The engine work was solid, and bored guides were universal. Drums were keyed fast, ends frequently cast separately, and connected by the body. In one large winch the drums were cast in halves and bolted over the shaft through lugs. In one of the brakes the blocks were gripped on opposite sides of the brake drum with right and left-handed screws, of quick pitch, working in nuts, and operated by a loaded lever, the nuts being attached to the ends of the brake blocks. L. Galland, of Chalon-sur-Saone, also showed double-drum winches, steam-driven. There were several novelties there, such as a double-drum winch with a pair of vertical engines between the drums, and balanced cranks; a double-drum engine with drums at right angles, one shaft being operated from the other by mitre wheels, and both driven from a single-cylinder engine.

This account includes the principal cranes in the Exhibition. Many others have been unavoidably left unnoticed, for the crane industry is one of great importance in France and Germany.



RIDDLES WROUGHT IN IRON AND STEEL

By Paul Kreuzpointner

Mr Kreuzpointner's remarks, discussing some of the notable phenomena observed in the working and use of iron and steel, appeared originally in the shape of a lecture delivered before the Franklin Institute. They are here reproduced practically in full as a most interesting and suggestive contribution to the literature of iron and steel metallurgy.—THE EDITOR.

IN view of our apparently extensive knowledge of the nature of iron and steel, it may seem strange to still speak about riddles wrought in these metals. Nevertheless, in everyday practice, we are constantly confronted by riddles of one kind or another, when dealing with iron and steel, particularly the latter.

One's ingenuity is sometimes taxed severely to find an explanation for the cause of such riddles. We pour some fluid iron or steel into a mould, and what have we? A metal liable to puzzle us with various kinds of often contradictory phenomena which may be of no consequence, or perhaps be annoying and sometimes hurtful.

We congratulate ourselves on having taken all precautions to insure a good casting, when lo! we hear a crack and find the subject of our pride a useless mass of metal. We say it was caused by shrinkage. Can anyone describe the laws according to which the various elements of which the metal is composed aggregate to themselves the proper percentage of the most congenial elements at the proper degree of heat in the most suitable time and in such a position as to be torn apart *en masse* at a given point during the cooling of the mass, and what causes the casting to crack on account of shrinkage? We know well enough how internal strains end, provided they end injuriously, if not disastrously; but who can solve the riddle of how they begin, how they progress, and how they stop just within, or far below, the point of rupture, as the case may be?

The riddle becomes no less puzzling if we roll that steel, if it was steel, into plates, use those plates for several years, and then all at once some of them begin to crack lengthwise and crosswise and are so brittle that a blow with a hand hammer breaks off strips of the material. Yet that steel met all chemical requirements and physical specifications before the plates were put in service and after they had disastrously failed.

When about twelve years ago the author called the attention of a foreign steel-maker to the fact that soft steel was being used very successfully in the United States for boilers, he said that would never do. He had known of steel plates cracking while leaning against a wall. Now, is this not curious? Why should steel plates crack after they had passed rigid specifications? And why should there be greater success in the use of steel in one country than in another? Why is it that one man softens a piece of steel by annealing, while another man anneals an identical piece of steel and finds it has become harder when his object was to get it softer? Here are a few figures. Wire with 49,200 pounds per square inch when unannealed was found to have a strength of 54,400 and 55,800 per square inch after annealing for several minutes in a temperature of from 1400° to 1500° F. In a series of twenty pieces of soft steel the author found not one of them softer after annealing. Two

of the pieces were of the same strength and elongation as before annealing, and all the others were harder and lower in elongation.

Why is it that we can raise the strength of soft staybolt iron of, say, 47,000 pounds per square inch, to 60,000 pounds per square inch either by heat treatment, or by repeated application of stress? Why is steel coming from the rolls or hammer weaker, and less ductile, than the same steel is after left lying a day or two, or, better still, a week?

There is no doubt that many tons of suitable material have been either thrown out by the mill people themselves or were rejected by the inspector because it failed to meet specifications, causing needless vexation and friction simply because neither the one nor the other of the parties knew that steel is in a disturbed physical state after rolling or hammering, no matter how good the material, and should be left to rest, the longer the better. Now, what takes place in the steel during the period of rest?

Another riddle is that we can raise the elastic limit and ultimate strength by a successive application of stresses very much above the original strength. What law, if it is a law, governs this phenomenon? Personally, the author is convinced that many errors of design or inherent weakness of the steel have been modified in their probable consequences, and breakdowns averted, by this peculiar property of steel to gain in strength, if allowed to rest after having been subject to stresses within certain limits. It was the knowledge of this fact which enabled the author to fight for steel and defend steel for structural purposes at a time when that metal was not yet a favourite with the engineer by any means. We are all familiar with the interesting discovery that cast iron becomes stronger by tumbling in a tumbling barrel, but for all we know it is still an unsolved riddle what the conditions really are that produce such effects.

There is reason to believe that a similar phenomenon takes place in steel and, by analogy, in other cast metals. In looking over a table of the different degrees of temperature at which a certain number of plates were rolled, from the first pass to the last, I found one plate where the temperature remained 1900° F. during three successive passes. In another plate, an inch thick, the temperature likewise remained 1900° F. during three successive passes. In still another one the temperature oscillated between 2190° and 2200° F. during five successive passes. Is this not a riddle?

When we look over the large field of results obtained by subjecting steel to strains of one kind or another we observe an almost endless variety of phenomena, which, on account of their frequent occurrence, may be familiar enough to us, but as to the reasons why, we are profoundly ignorant, showing us that our knowledge of steel is still rather fragmentary, notwithstanding the great strides we have made in the knowledge of the properties of that valuable metal.

If we heat a steel bar at one end, having divided it previously into inch lengths, and then break off the pieces, one after another, we will find the structure of the fifth or sixth piece very much different at both the fractures, though they are only an inch apart. Either one of the fractures is coarse-grained and the other very fine, or the one is granular and the other amorphous.

What does such a puzzling phenomenon teach us? Sometimes we are taught something which in after life we find not to be correct. Thus, fifty years ago I was taught in school that elephants could not get up if they ever fell down. I was very much surprised when I saw an elephant for the first time and found he could lie down and get up like a horse.

We have likewise been told that elongation is proportionate to strength, that the one increases as the other decreases, and *vice versa*. Everyday experience does not bear out this assertion. Looking over a list of 150 tests of steel of the axle grade, ranging from 74,000 to 103,000 pounds per square

inch, an elongation is found of 27 per cent. at 76,000, 88,000, and 96,000 pounds strength; 20 per cent. is associated with every result from 80,000 to 99,000 pounds; 18 per cent. goes with 80,000 and 100,000 pounds; while 16 per cent. accompanies 85,000, and 103,000 pounds. What causes this apparent anomaly?

Let us take the product of two different steel works, and if we test it in 8-inch section, the tensile strength and elongation may be found alike in both cases. Yet if we test the same steel with a 2 or 4-inch section we may find a difference of from 4000 to 6000 pounds per square inch, and several per cent. of elongation between the two products. Here we have not only a riddle, but a powerful argument why we need uniform methods of testing, and that it is in the interest of manufacturers as well as the engineer to bring about such uniformity.

Right in line with this puzzle is that other puzzle, shown first by Bauschinger and Wöhler, and confirmed since by numerous investigators, that removal of the load which is straining a piece of metal does not stop the activity of molecular motion in that piece, but that activity, once aroused, continues for days, weeks, and months after the load has been removed. Thus, for instance, if a test-piece has been stretched somewhat beyond the limit of proportionality it will, on removal of the load, return partly to the original length at once. It will not stop there, however, but will continue to grow shorter for weeks and months, more rapidly at first, but slower and slower afterwards.

Let us consider now some of the manifestations which apparently are the source of many of the riddles we come across! To solve these riddles must be our constant endeavour if we are not to retrograde in the art of applied metallurgy. One of the principal, though not the only, sources of the riddles we encounter in steel and other cast metals is, no doubt, the characteristic of alloys to segregate. This tendency to segregate does not necessarily mean the formation of a nodule of some size within a shrinkage cavity of a chemical composition entirely different from the surrounding mass, or the lining of a shrinkage cavity with those pine-needlelike crystals so characteristic of iron alloys, nor yet of the formation of hard spots.

While all of these are common occurrences, yet we have to look for an explanation of some of the riddles wrought in steel to that kind of segregation which produces a chemical change in the whole mass of steel and makes itself felt by a change in the whole structure rather than in separate spots. That eminent metallurgist, Freiherr Jüptner von Jornsdorf, in speaking of the problems we have to deal with in metallurgy, says:—

"All accumulated experience points to the conclusion that in metals we are dealing with solutions, and that the various components are segregations, the nature of which depends, of course, on the various elements of which the solution is composed and the temperature at which these elements separate. That this process of separation on cooling varies according to the point of saturation of the solution is well known.

"In a concentrated solution a part of the dissolved elements segregate out at a decreasing temperature. On further cooling, still more of the elements segregate out, until, at a certain point of temperature and concentration, the remaining mother liquor, that is, the solvent, and the dissolved elements solidify together without further segregation of the one or other element. * * * * In practice this phenomenon may become complicated in so far that, for instance, a concentrated solution of the one or the other element is present in the molten alloy. On cooling, the excess of this element segregates out, and the remainder, or mother liquor, represents a diluted solution. If, now, on further cooling, part of the solvent segregates out, then it is conceivable that a reversal of the previous condition takes place, and the mother metal again becomes a concentrated solution."

This may give us an idea of the complexity of conditions and distribution of elements in cast iron and steel, due to their separating and segregating at

different temperatures in ever-varying percentages. Thus we can readily imagine the almost incomprehensible complexity of conditions, arising in a cooling mass of cast iron or steel, especially of cast iron, which is richest in divers elements, by the partial or complete absorption, saturation, equalisation, segregation, exchange and interchange of the various elements, according to their affinity, the law of crystallisation governing them, degree of melting heat and rate of cooling. In these reciprocal effects of absorption and segregation, of solution and saturation of the varying and ever variable elements composing cast iron and steel, complicated still more by the melting point and rate of cooling, we no doubt often may find the reasons for at least some of the riddles wrought in iron and steel. As we go down in the scale of temperatures, from the highest degree of fluidity to the point of complete solidification, we have a series of formations of groups of elements, the last of which decides the quality and usefulness of the metal.

Conversely, when heat is applied to a solidified mass of metal, the various groups of elements will not soften and melt simultaneously, but in succession, and herein we find the source of many riddles and complexities due to the heat treatment of steel.

It is, indeed, an indisputable fact that we can spoil a good piece of steel by improper heat treatment and can improve an inferior grade of steel by proper heat treatment, and we can also produce different qualities in the same piece of steel by a judicious heat treatment.

[Mr. Kreuzpointner here exhibited a series of four microphotographs of steel specimens, each of which showed a different structure, as well as a different tensile strength and ductility, although the four pices were one and the same piece of steel, having had exactly the same structure and physical qualities and chemical elements originally. The first photograph showed the original steel. Its tensile strength was 103,000 pounds per square inch and elongation 15 per cent. in 2 inches. The carbon was 0.4 per cent., and the high strength, as well as the appearance and irregularity of structure for this grade of steel, indicated internal strains. The original piece having been cut into four pieces, piece No. 2 was heated to produce what the author considered normal axle steel. The structure had become quite uniform and more open-grained than in No. 1. The tensile strength had fallen to 87,000 pounds per square inch, and 35 per cent. elongation in 2 inches, a decrease of 16,000 pounds per square inch and increase of 20 per cent. elongation. A third piece was heated in a different, though not unusual, way. This brought the tensile strength down to 84,000 pounds per square inch and 22 per cent. elongation in 2 inches. The structure had become coarse, showing a distinct separation into two well-defined bodies of metal. The fall in strength and elongation indicated impaired quality of the steel. The fourth piece was then annealed to a high degree of heat and left to "soak" for two and one-half hours. The strength in this had fallen to 80,000 pounds per square inch and 20 per cent. elongation in 2 inches. The structure had changed radically, and clearly showed overheating.]

Now let us suppose that such varying degrees of heat or modifications of them are applied to the members composing a structure, or to the individual pieces of a lot or shipment; then we can readily imagine the almost endless variety of structures in the steel of perhaps a day's work, of comparatively uniform chemical composition, and, what is still more important, the ordinary specifications for tensile test may bring all these structures, good, bad, and indifferent, within the limits of acceptance. Do we need to wonder if we find riddles wrought in that metal?

Other instances could be given to show how comparatively little we know yet about steel, and how much there is yet to learn when we can produce at will a difference of 23,000 pounds per square inch of strength and 20 per cent. of elongation in the same piece of steel at the same time. In another case, the author succeeded in producing a difference of 21,000 pounds. In producing

such differences, hardening of the metal is not taken into consideration.

While our knowledge of the causes and effects of the action and reaction taking place in steel is as yet rather fragmentary,—hence the riddles,—yet we are beginning to grasp the underlying principles. We know now that steel is an alloy in which a part of the elements is held in solution by the iron, while part is a mechanical mixture. We are beginning to learn that there is no stability between the relations of the various elements at each and every stage of the life of steel. We are comprehending that iron and steel are not the rigid, immovable mass we were wont to consider these metals, that they are, in fact, like very sensitive creatures, liable to be influenced by changes of temperature, unwilling to be abused and ill-treated.

It is the degree of this changeability of steel which to-day requires our closest attention and study, the condition under which it changes, the reasons why it changes, and what changes make a given grade of steel suitable or unsuitable for a given purpose. The want of this knowledge causes many phenomena to appear as riddles to us at present. What we need to do now is to make use of the susceptibility of steel by changing its nature to our advantage in producing the most suitable quality, at one time, or, at another time, to secure greatest possible uniformity, not only in one piece, but in a number of pieces.

We must use the pyrometer more freely than we do now in order to be able to determine the proper temperature at which to anneal and to temper and to produce the same results uniformly at all times. We must discard thumb-rule and guesswork in the treatment of steel, just as we have discarded thumb-rule and guesswork in mechanics. We must study the micro-structure of steel in its relation to physical qualitics and chemical constituents. We must find the best methods how to measure and determine the properties and qualities of steel.

The author is well aware of the practical difficulties of doing all this, but this should not hinder us from adapting our methods of testing and investigating the qualities of steel as closely to its nature as we know how and to the condition under which we use it. At present we often follow the old, beaten path without paying due attention to changes in economic conditions and our improved knowledge. Some of the riddles encountered in iron and steel are not riddles in the sense that they are indications of a perversity of these metals, but they are simply and solely due to our tendency to treat the physical properties of iron and steel as things which can be measured like other chemical constituents, in the chemist's balance, or conform themselves to every notion we may have about the manner and method in which these metals are finished, tested, and worked.

Since we are beginning to learn what peculiar effects heat treatment has on steel, we must go a step further in our progress and determine the finishing heat, the tempering heat, the annealing heat, the quenching heat, with the aid of the pyrometer, for a given grade of steel. If we are satisfied with wide ranges of the qualities in steel, we may go on in the ways we have followed thus far. But if we want to use our resources to greatest economical advantage and be tolerably sure what we are doing in order to be sure what we are getting, we must adapt the means to the end in proportion as we progress in our knowledge.

BRITISH VERTICAL STEAM ENGINES

By W. D. Wansbrough

THE long-stroke, horizontal steam-engine discussed in this magazine for May, 1900, finds no counterpart in the vertical type. Other conditions than those there considered operate in the direction of maintaining the required speed of piston by increasing the number of reciprocations with a correspondingly reduced length of crank. Hence, with the exception of two or three special types, of which we shall take account presently, the prevailing type of vertical engine now manufactured in Great Britain approximates closely to the marine pattern, although no land engines at present in use come anywhere within reach of those marine monsters in which the builders, greatly daring, have concentrated many thousands of horse-power into a single unit.

It is a curious fact in connection with vertical land engines that, outside the domain of electricity, they are, as a rule, (of course, with exceptions) either very large, in the shape of blast engines for ironworks, or very small, in the form of combined engines and boilers for agricultural purposes, or small manufacturng trades. The former, however, are omparatively few in number, while the tter, though scattered throughout the untry by thousands, are gradually, for ustrial purposes, being supplanted b gas engines.

ence, a review of modern British ve al engines practically resolves itsel to a consideration of the principal cur t types of engine in use for generat electricity in its various applications That ever-broadening field of indus has given a new impetus and a new ortance to the vertical pattern of stea ngine.

From the very numerous illustrations with which the writer has been favoured by the leading makers, considerations of space prevent doing more than quoting representative examples of each type, although it is a little difficult to draw a hard and fast line in some instances; and it should be noted that in nearly every case where compound engines are shown the makers are also prepared to supply triple-expansion engines of the same class, and *vice versa.*

The engines illustrated may be classified as follows:—

I.—Open-type engines, sometimes partially enclosed by removable splash-guards, with length of stroke considerably exceeding the diameter of the high-pressure cylinder. The fine pair of engines contributed by Messrs. Victor Coates & Co., Ltd., of Belfast, shown in Fig. 1, are an example of this class. The admission and exhaust valves in both cylinders are of the Corliss type, and the gear is very ingeniously brought to the front, thus reducing the length of the engines,—a very important consideration where space is limited. The crankshaft, it will be noticed, is built-up, as in marine practice. The crossheads are of the slipper type, although the steel tie-rod, or leg, usual in engines of this construction, is here replaced by a cast iron front standard to which the rocking levers of the valve motion are conveniently attached. Being intended for driving a factory, the particular engine shown is fitted with a grooved fly-wheel, outside which a third bearing is provided. Messrs. Coates make a specialty of large-sized vertical engines for general driving purposes.

Messrs. Mather & Platt, Ltd., of Manchester, build a triple-expansion condensing engine, shown in Fig. 2, coupled to one of their own multipolar,

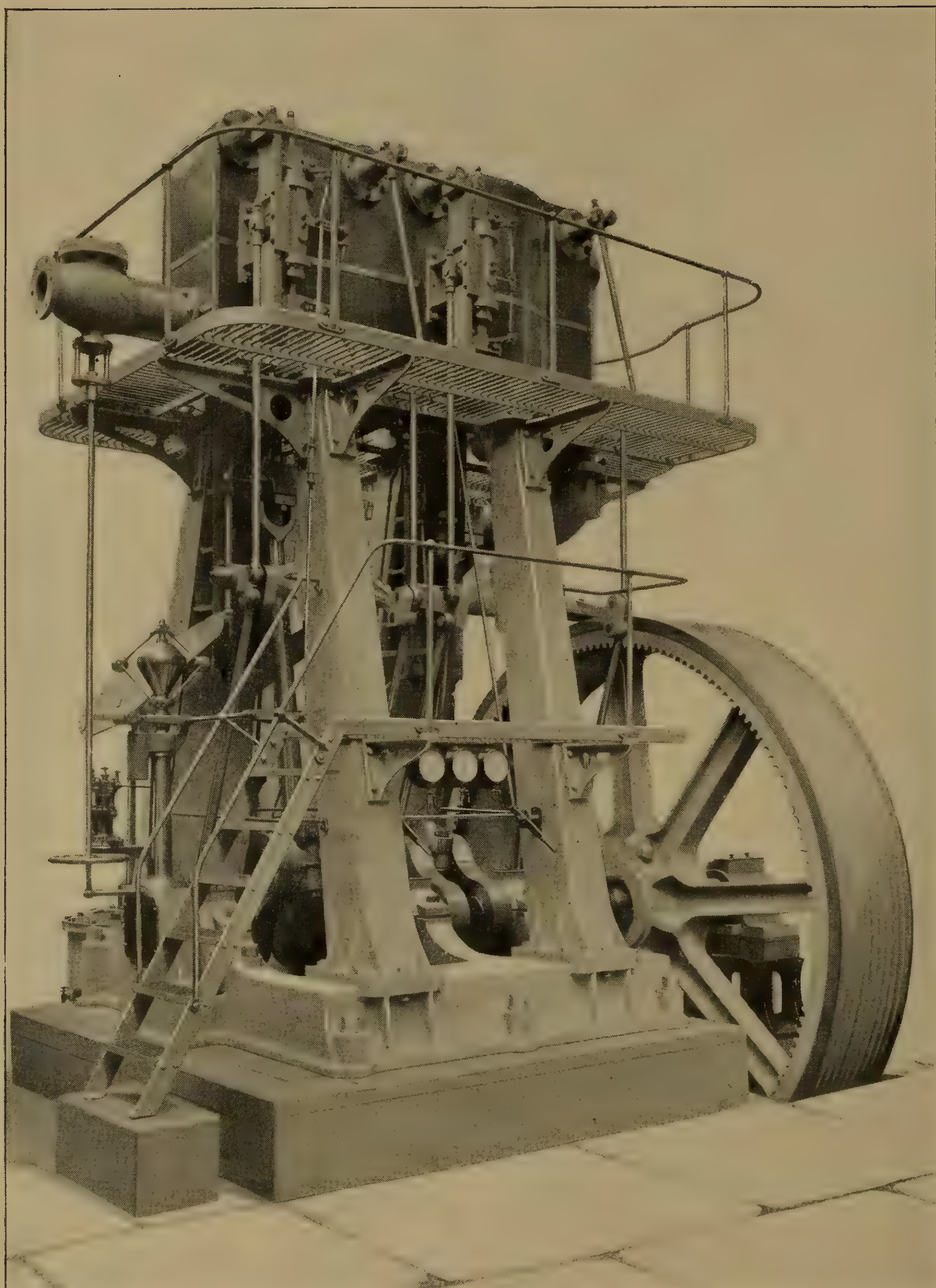


FIG. I.—COMPOUND ENGINE BUILT BY MESSRS. VICTOR COATES & CO., LTD., BELFAST

continuous-current dynamos, the particular engine illustrated being one of a group of seven. The cylinders are 17, 28, and 45 inches in diameter by 21 inches stroke, revolutions 120 per minute, giving, with 185 pounds steam pressure at the stop valve, 850 H. P. as a maximum. These engines run night and day for eighteen weeks at a time without a single stop, sufficient testimony in itself of their excellence in design and workmanship. All three cylinders are fitted with piston valves, the governor being of the crankshaft type acting upon an equilibrium throttle valve. The splash-plates are of glass, for convenience of observation of the working parts.

Messrs. Pollit & Wigzell, Ltd., of Sowerby Bridge, Yorkshire, furnish still another example of comparatively long-stroke, vertical engines in Fig. 3. The design of this engine differs essentially from any of those preceding. The

back standard with slipper guide and steel or cast iron front column is here replaced by a pair of *A*-frames, the crosshead pin being extended at each end to carry the guide blocks. The splash-plates which close in the front and back of the engine have been removed to show the construction of the engine. Corliss steam and exhaust valves are fitted to both cylinders, controlled upon the high-pressure cylinder by a Hartnell governor running on ball bearings and acting upon the firm's patent high-speed trip gear. The engine illustrated is of 600 I. H. P., cylinders 17 and 34 inches by 30 inches stroke, running at a speed of 124 revolutions per minute, with a working pressure of 150 pounds per square inch. A steam consumption is certified to of 14.4 pounds and 14.5 pounds per I. H. P. per hour, respectively, in the case of two condensing engines, similar in size and design to that illustrated, when indicating 476 and 484 horsepower.

We now turn to the second class:—

II.—Open or partially enclosed engines of shorter stroke,—approximately equal to the diameter of the high-pressure cylinder,—a very numerous class, generally of smaller powers than those just noticed. For very small electric light installations single cylinder engines are extensively used. Three examples are shown, illustrating three different systems of governor. That by Messrs. Ransomes, Sims & Jefferies, Ltd., of Ipswich, Fig. 4, coupled to a dynamo upon the same bedplate, is controlled by an equilibrium throttle-valve worked by a governor on the crankshaft. A somewhat similar governor on Messrs. Robeys' single-cylinder engine, Fig. 5, acts directly upon the valve, which is of the piston type, forming a simple and effective automatic expansion gear; while Fig. 6, by the same makers, exhibits their well-known "EL" governor, driven by belt, and adjustable as to speed by screwing in or out the milled nut at the top, which can be done while the engine is running. Messrs. Robey & Co., Ltd., make

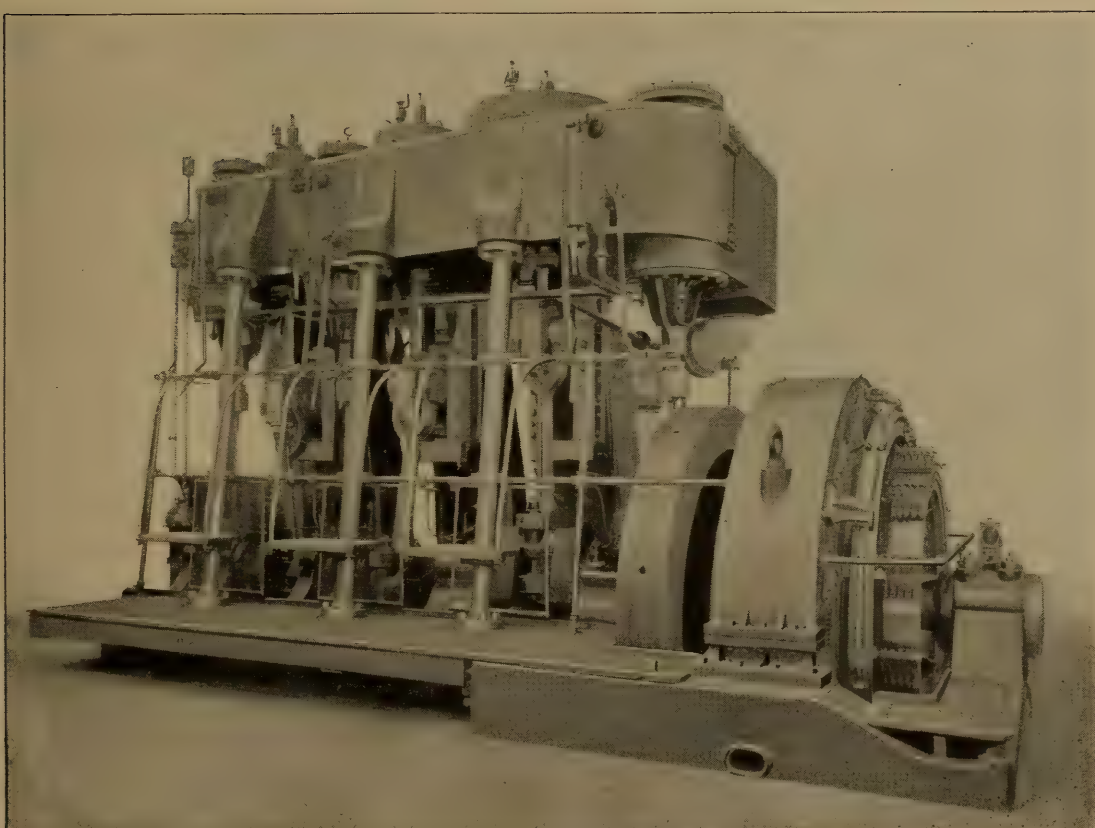


FIG. 2.—TRIPLE EXPANSION ENGINE BUILT BY MESSRS. MATHER & PLATT, LTD., MANCHESTER

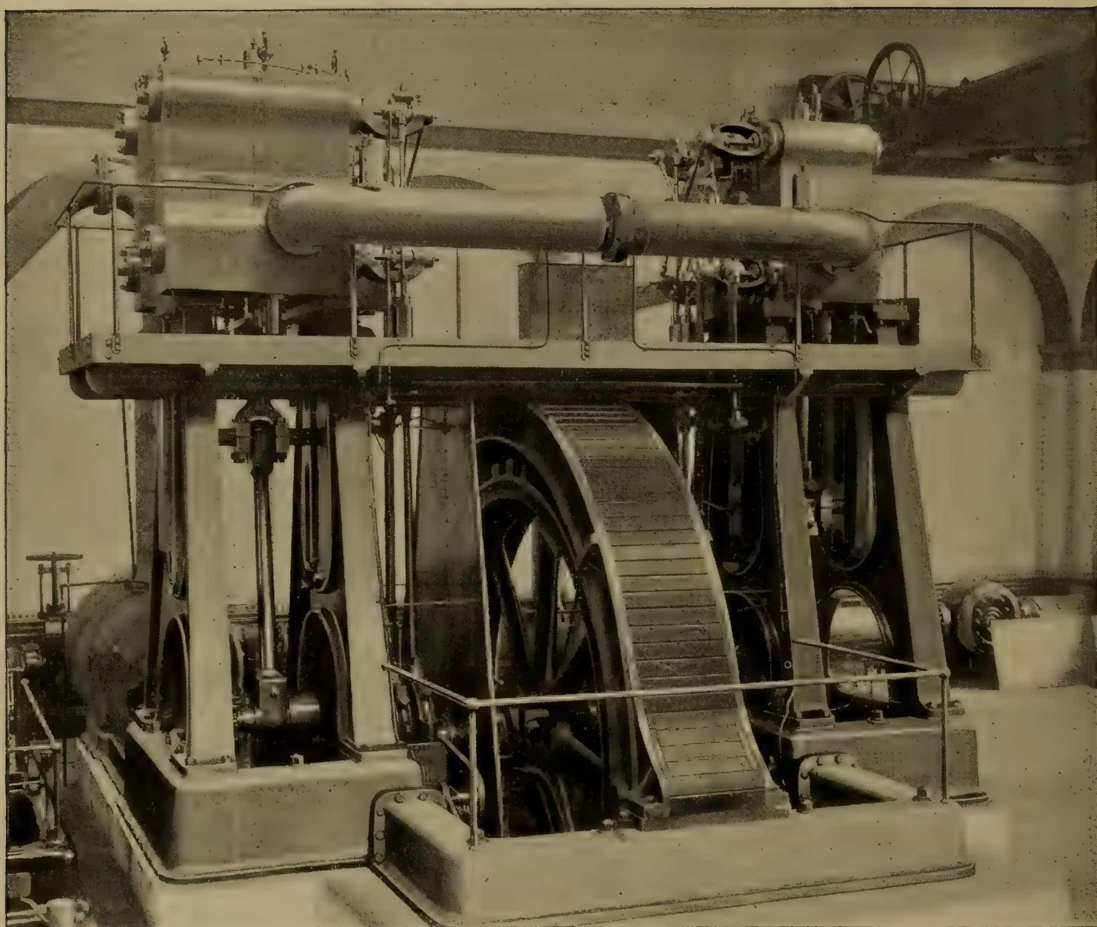


FIG. 3.—COMPOUND ENGINE WITH ALTERNATOR. BUILT BY MESSRS. POLLIT & WIGZELL, LTD., SOWERBY BRIDGE

single-cylinder engines of this class from 4 inches to 14 inches of stroke, the sizes ranging thus:—4½ × 4 in.; 5½ × 5; 6½ × 6; and so on, up to 14½ in. by 14 in., each size rising by one inch, the brake horse-power at maximum speeds being at 100 pounds pressure, from 6½ up to 140. For steam pressures lower than 50 pounds larger cylinders are provided, the 4-inch stroke engine having a 5½-inch cylinder, and so on proportionately up to a 19¾-inch cylinder in the 14-inch stroke engine.

Further examples of this useful class of engine, compounded, are shown in Figs 7 and 8. In Fig. 7 Messrs. Ransomes' compound, open-type engine, with automatic expansion by shaft governor, is shown coupled to its dynamo. Both cylinders are fitted with piston valves, and there is a neat form of hinged splash-plate. This engine is also fitted with a separator,—an adjunct very well worth having, whether included in the price of the engine or not.

Fig. 8 illustrates Messrs. Davey, Paxman & Co.'s "Windsor" type,—an open-front, compound engine with link-expansion gear controlled by a powerful high-speed governor not visible in the illustration. Here, it will be observed, the extension for the dynamos is in one piece with the bedplate of the engine.

We now come to the third division, viz:—

III.—Double-acting engines in which the length of stroke is very much shorter than the diameter of the high-pressure cylinder. For reasons which will be immediately evident these are always "enclosed" and "self-lubricating" engines. The term "high-speed" engines is quite correctly applied to the class with which we have just dealt.

There are, however, many long-stroke, horizontal engines in which the piston speed is high enough to entitle them to be classed as high-speed engines; and conversely, an engine of, say, 6 inches stroke, making 500 revolutions per minute, is rather a slow-speed engine, as piston rates are reckoned nowadays. Perhaps the name "quick-rotation" engines may serve to distinguish the class of very short-stroke engines about to be considered, examples of which are shown in Fig. 9, representing a compound type, and Figs. 10 and 11 representing triple tandem designs.

This type was undoubtedly originated by Messrs. G. E. Belliss & Co., of Birmingham, now Belliss & Morcom, Ltd., who, in the year 1890, after much experience with very fast-running torpedo-boat machinery, evolved the idea of applying to their high-speed engines an artificial system of circulating oil under pressure through the bearings by means of a force-pump. This plan had long been in use by both British and Continental makers for oiling the main bearings of large horizontal engines, but this does not detract from the ingenuity displayed in successfully adapting the method to crosshead and crank-pin bearings moving at a rate which renders them almost invisible.

The single-acting, constant-thrust engine, which had long held the field for high rates of rotation, was at once confronted with a formidable rival; and the alternating upward and downward pressures of the connecting-rod brasses upon the crank-pin, so long reckoned the special disadvantage at high speeds of the double-acting engine, was actually converted into the means of getting the lubricant between the opposing surfaces,—"the friendly lift which lets the oil in," as it has been called.

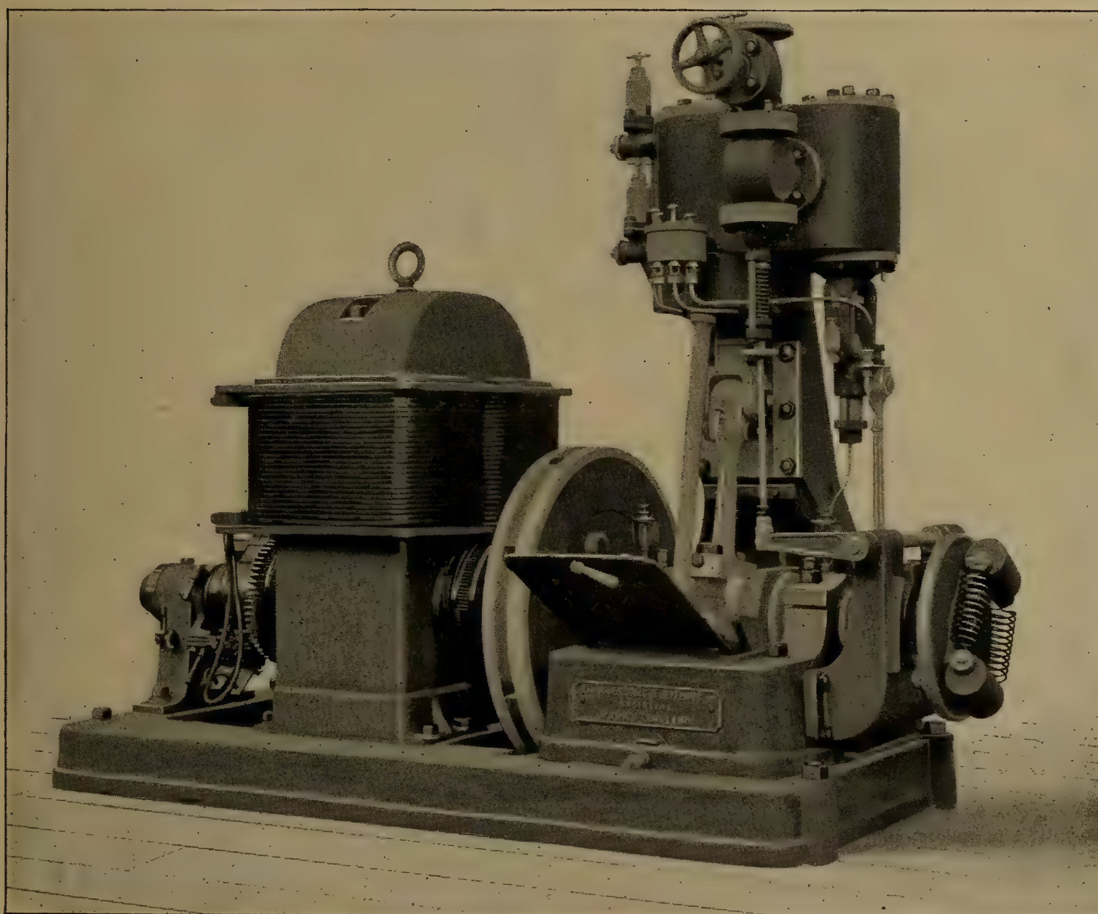


FIG. 4.—SINGLE-CYLINDER HIGH-SPEED ENGINE BUILT BY MESSRS. RANSOMES, SIMS & JEFFERIES, LTD., IPSWICH

In looking over the published utterances of the partisans of the two opposed methods of lubricating bearings in rapid motion,—the oil bath, or "splash" systems, and the plan of forced lubrication,—it is impossible to avoid the conviction, almost amounting to certainty, that each, in turn, is the best of all possible systems. The evidence in support of each appears to be incontestable, the results, after years of constant use, given in terms of diametrical wear of the working surfaces, being absolutely surprising. Taken together, they afford convincing proof that, at the very highest rate of rotation in properly constructed engines, the effects of wear and tear are practically negligible quantities. The traditional engine-driver, with the officious oil can and the corrective cotton-waste, finds his occupation gone with engines which, in the words of Mr. R. E. Crompton, "only stop at Christmas for an annual cleandown, working uninterruptedly for the rest of the year."

Figs. 12 and 13 show in section the forced-lubrication, compound engine of Messrs. Belliss & Morcom, Ltd. It

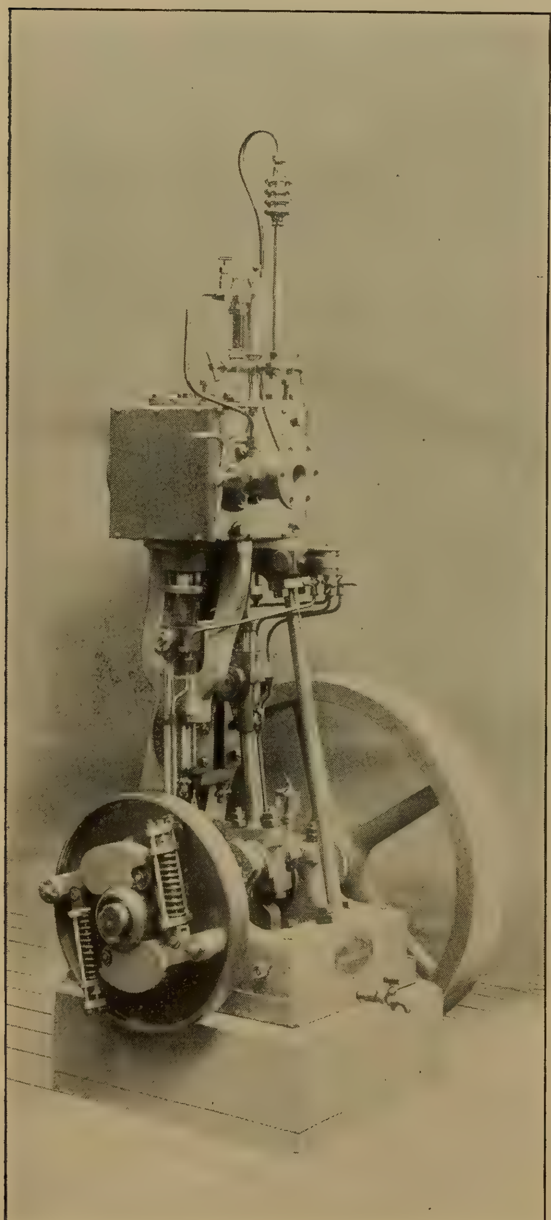


FIG. 5.—SINGLE-CYLINDER, AUTOMATIC ENGINE

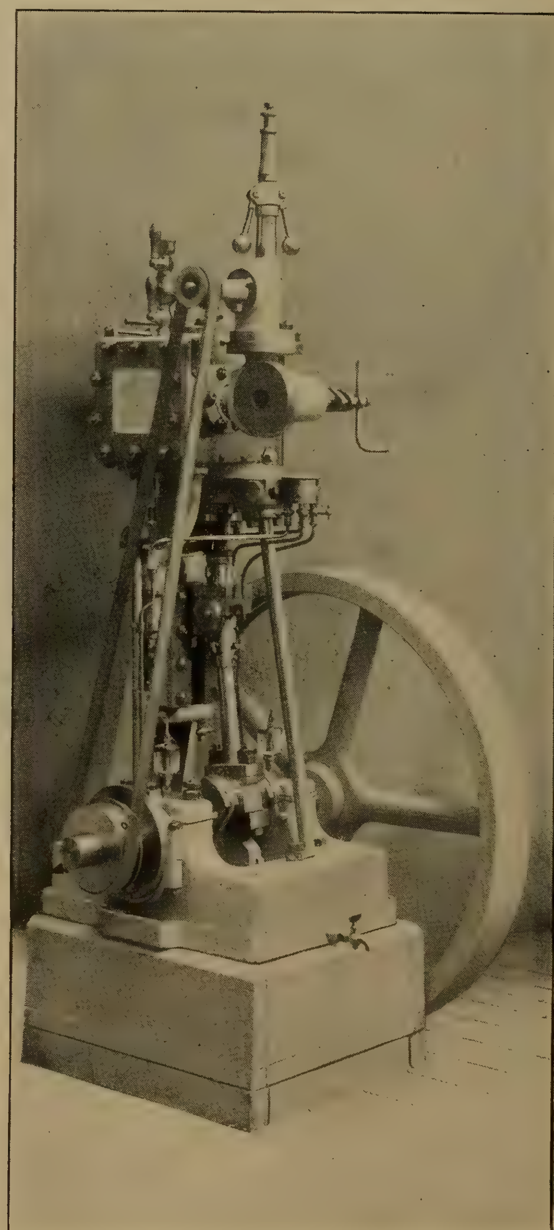


FIG. 6.—SINGLE-CYLINDER THROTTLING ENGINE

BUILT BY MESSRS. ROBEY & CO., LTD., LINCOLN

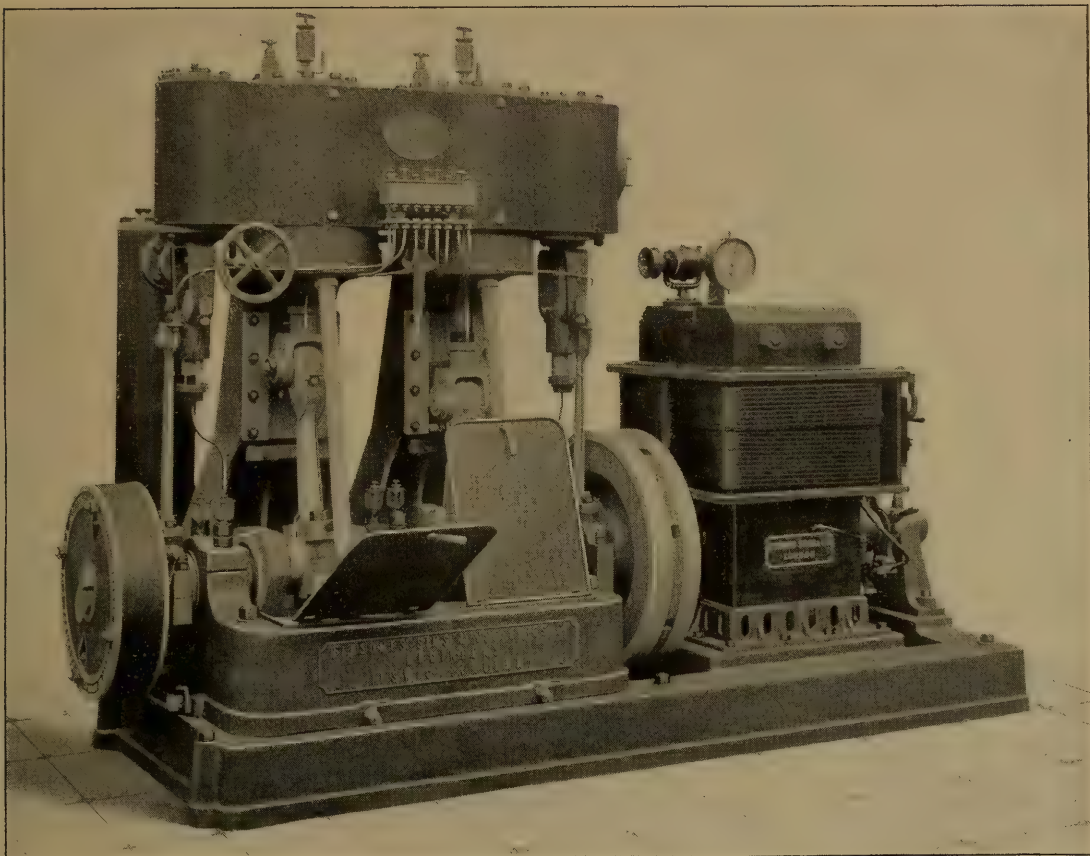


FIG. 7.—COMPOUND ENGINE BUILT BY MESSRS. RANSOMES, SIMS & JEFFERIES, LTD., IPSWICH

will be noticed that the whole of the working parts are enclosed in a casing, forming the frame of the engine, and usually known as the crank-chamber. The lower part of this chamber is filled with oil to a depth just below the lowest reach of the connecting-rods. There is, therefore, no splash, and the engine can be run under inspection, if desired, with the large doors in the casing wide open. A small oscillating force pump, worked from the valve eccentric, forms the active principle of the arrangement, and from its delivery branch small tubes lead directly into the caps of the main bearings.

Each crank, as will be seen from the engravings, has a small hole drilled diagonally from a point about midway in the adjacent main bearing, emerging at the surface of the crank-pin. The connecting-rod "brass" is similarly perforated, and the oil from the main bearing passes through the first-named channel to the crank-pin,—it should be understood that we are tracing the course, not of a few drops, but of a powerful stream of oil under pressure, —and then escapes upwards through a pipe fixed alongside the connecting-rod to the crosshead pins and thence to the guide surfaces. The single eccentric-strap and valve-rod joint are treated in the same way, so that every joint in the engine is self-lubricating.

There is no return circuit, the current of oil going, so to speak, direct to earth as it passes out from each bearing,—in other words, falling back to the crank-pit, whence, after passing through a strainer, the same oil is circulated *ad infinitum*.

This is scarcely an exaggeration, for, strange though it may seem, the total quantity of oil present has a tendency to increase rather than to diminish,—doubtless owing to incidental drops of water getting in. At the outer end of each main bearing the escaping oil is intercepted by a small collar on the crankshaft, which spins the oil off at its circumference into the surrounding light

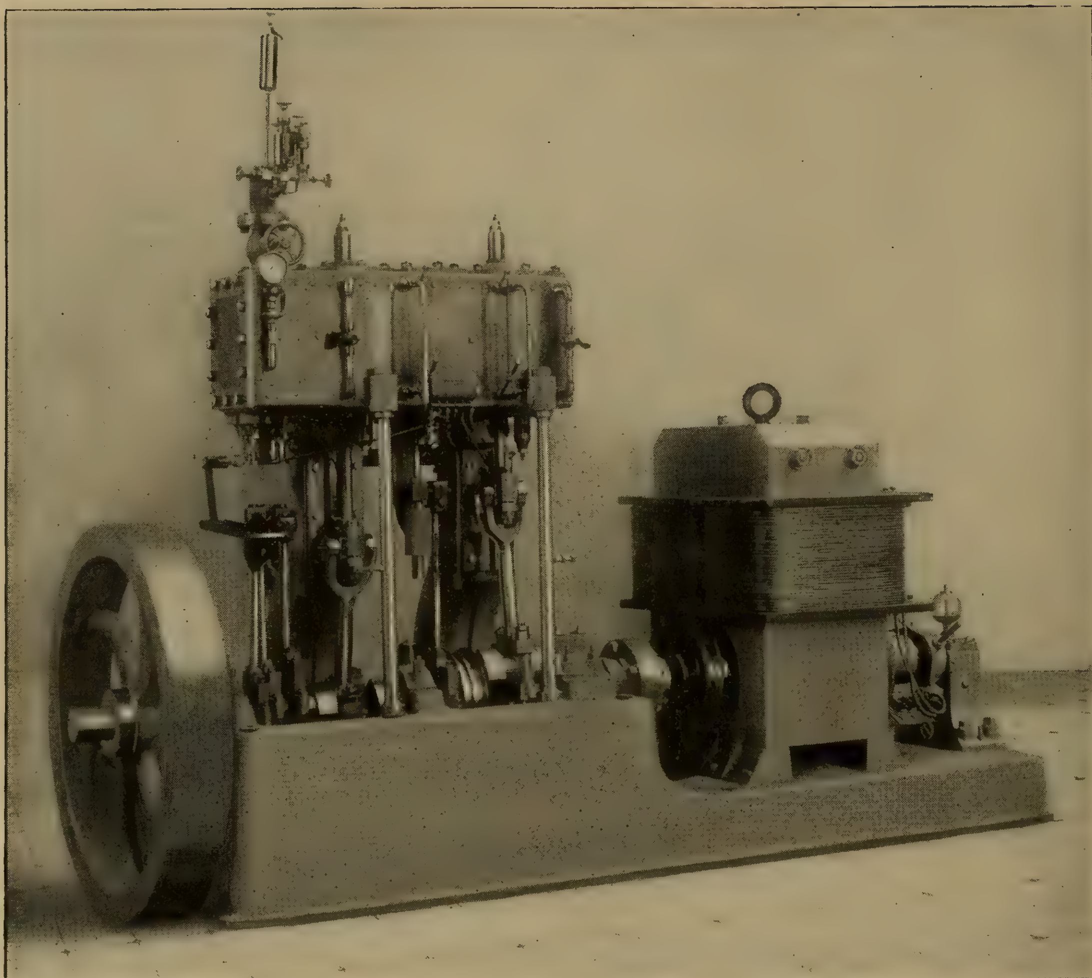


FIG. 8.—COMPOUND VERTICAL ENGINE BUILT BY MESSRS. DAVEY, PAXMAN & CO., LTD., COLCHESTER

casing from which a drain underneath the bearing conducts it back to the crank-pit.

This method of lubrication, with but slight variation, is employed also by a number of other builders of this type of engine. In Messrs. Robey & Co.'s engines the oil follows a different course, so far as the slides, crosshead pins, and crank-throw bearings are concerned. The oscillating valveless pump,—an idea borrowed from the steam cylinders of another type of high-speed engine largely patronised by the rising generation,—delivers its oil into a large vertical pipe, or rising main. From this branches lead off to the three main bearings, the oil being introduced at the point of least pressure, at the edges of the half-brasses, not at their crowns. A second pair of branch pipes deliver a stream of lubricant under pressure to the crosshead slides, coming in at a point exactly half way up. The crossheads are of the single-slipper type, each slipper-plate being of a length somewhat greater than the stroke, and having near each end a port cut through it, communicating with the crosshead pin, and (by a pipe leading down the connecting-rod) with the crank-pin also.

The effect of this is that the crosshead acts as a sort of distributing valve for the oil, which, at or near the ends of the stroke, at the instant of reversal of stress upon the connecting-rod, is admitted full bore to the large and small-end brasses, while throughout the remainder of the stroke the pressure of the crosshead upon the slide surface is borne upon a film of the lubricant. A third pair of branch pipes from the rising main lead to the valve-rod plunger guides, thence by two passages to the joint-pin and the eccentric strap, respectively.

The engine to which this arrangement

was first applied was allowed to run for exactly two years at a speed of nearly 500 revolutions per minute, without examination and almost without attention. At the end of that time it was opened for inspection, when the wear was found to be so trifling that the engine was immediately put together again without adjustment. An incidental, but not unimportant, advantage of the system just described is that the necessity of boring the crankshaft is done away with, while the flow of the oil to the surfaces in rapid motion is always downwards.

In engines of the forced-lubrication type the mechanical efficiency, or the fraction $\frac{B.\ H.\ P.}{I.\ H.\ P.}$, reaches a very high figure. Professor Kennedy records a result of 96.3 per cent. efficiency at maximum power in connection with trials made by him of a 200-H. P. Belliss compound condensing engine. At the same trial some remarkable results in the way of economical steam consumption at light loads were obtained. The water used per *B. H. P.* at maximum load was 18 pounds per hour; at normal load it was 18.2 pounds; at three-quarter load, 18.7 pounds; at half load, 19.8 pounds; and at one-quarter load, exactly 20 pounds!

Let us very briefly examine the construction of the engine shown in Figs. 12 and 13 as a type Apart altogether from any specialties, but considered simply as a compound vertical engine, look at the crankshaft and connecting-rods, the crossheads and slides, the piston-rods and stuffing-boxes! Would not these proportions have been regarded as absurd not very many years ago? Yet these, and such as these, are the standard to which all successful double-acting, quick-rotation engines now conform. The dynamo engine of the present day has, broadly speaking, been evolved by a sifting process in the first instance. Complicated valve gears have gone the way of the steam-jacket, and the stern dictation of necessity has pruned away non-essentials and left us

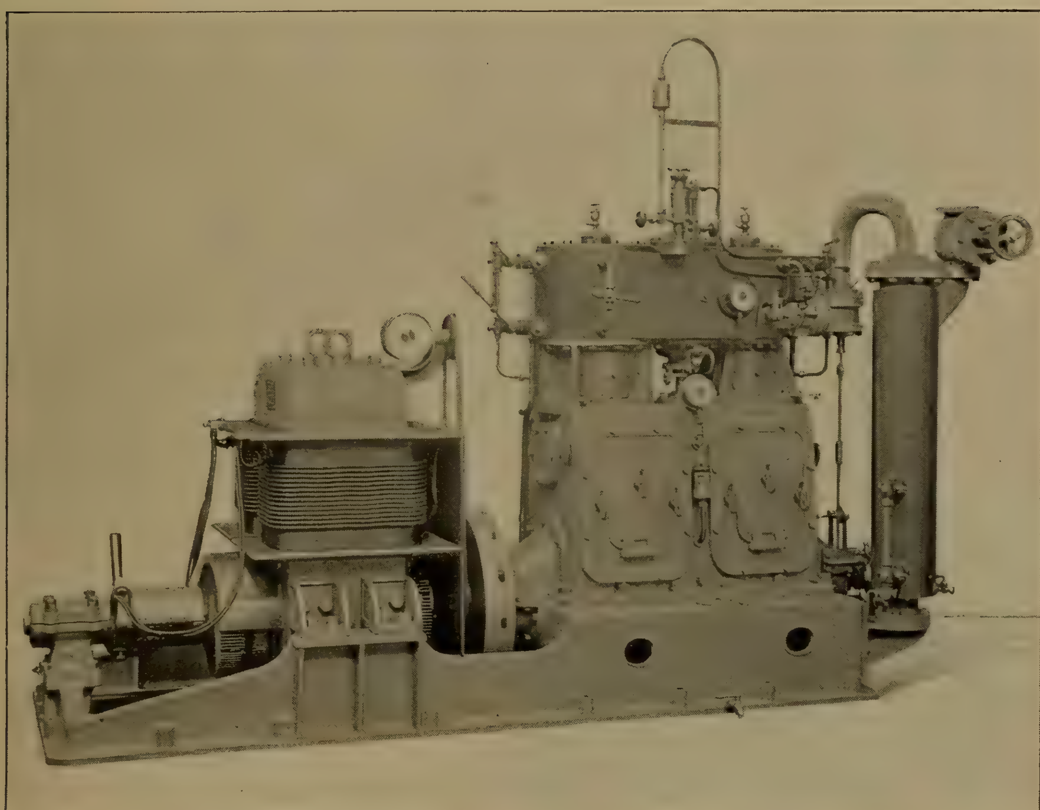


FIG. 9.—COMPOUND ENGINE AND DYNAMO BUILT BY MESSRS. SCOTT & MOUNTAIN, LTD., NEWCASTLE-ON-TYNE

with an engine elementary in form, severely accurate in construction, and almost exaggerated in strength and massive proportion.

The slightest deflection of the crankshaft from the true axial line, while running at speeds such as these engines are intended for, would give rise at once to conditions fatal to either quiet running or durability. Hence, the crank must be very short and very stiff; the journals perfectly cylindrical; and, in addition, the crank-pins must be truly parallel with the axis of the shaft. It will be seen that the whole of the crankshaft, except for those parts of its length actually occupied by the webs, the eccentric, the fly-wheel, and the governor, is utilised for bearing surfaces The cranks are placed at 180° apart, and are not counterweighted; and the two pistons, though of different diameters, are equalised in weight, with the object of balancing one engine against the other.

One piston valve, or rather two valves upon one spindle, effect the distribution of steam for both cylinders, the lower valve receiving the high-pressure steam at the centre and exhausting at the ends into the upper or low-pressure valve, which is of the end-admission and central-exhaust type. There are no packing rings, the valves, if carefully made and accurately fitted in the first instance, giving no trouble from leakage at these very high speeds.

Messrs. Allen, Son & Co., of Bedford, use a separate piston valve for each cylinder of their engine of this type; Messrs. Robey & Co. use a central-admission piston valve for the high-pressure, and a slide valve for the low-pressure cylinder, the object in each case being to get the cylinders, and consequently the cranks and reciprocating parts, as near to each other as possible, to the lessening, as far as may be, of the "rocking couple," or tendency of the engine, as a whole, to lift at each end alternately while running. In all these engines it may be noticed that the glands and stuffing-boxes are accessible without opening the casing or crank chamber. The governor in every case is in character with the remainder of the

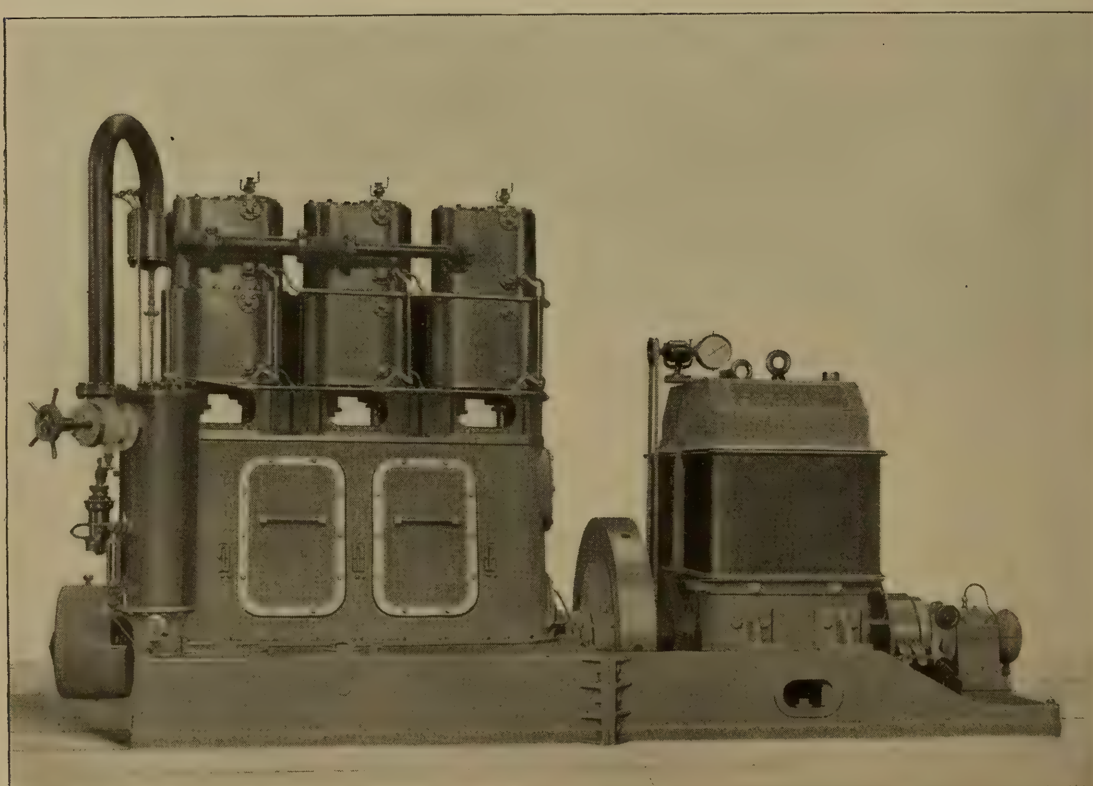


FIG. 10.—A THREE-CRANK, TRIPLE TANDEM ENGINE AND DYNAMO BUILT BY MESSRS. BELLISS & MORCOM., LTD., BIRMINGHAM

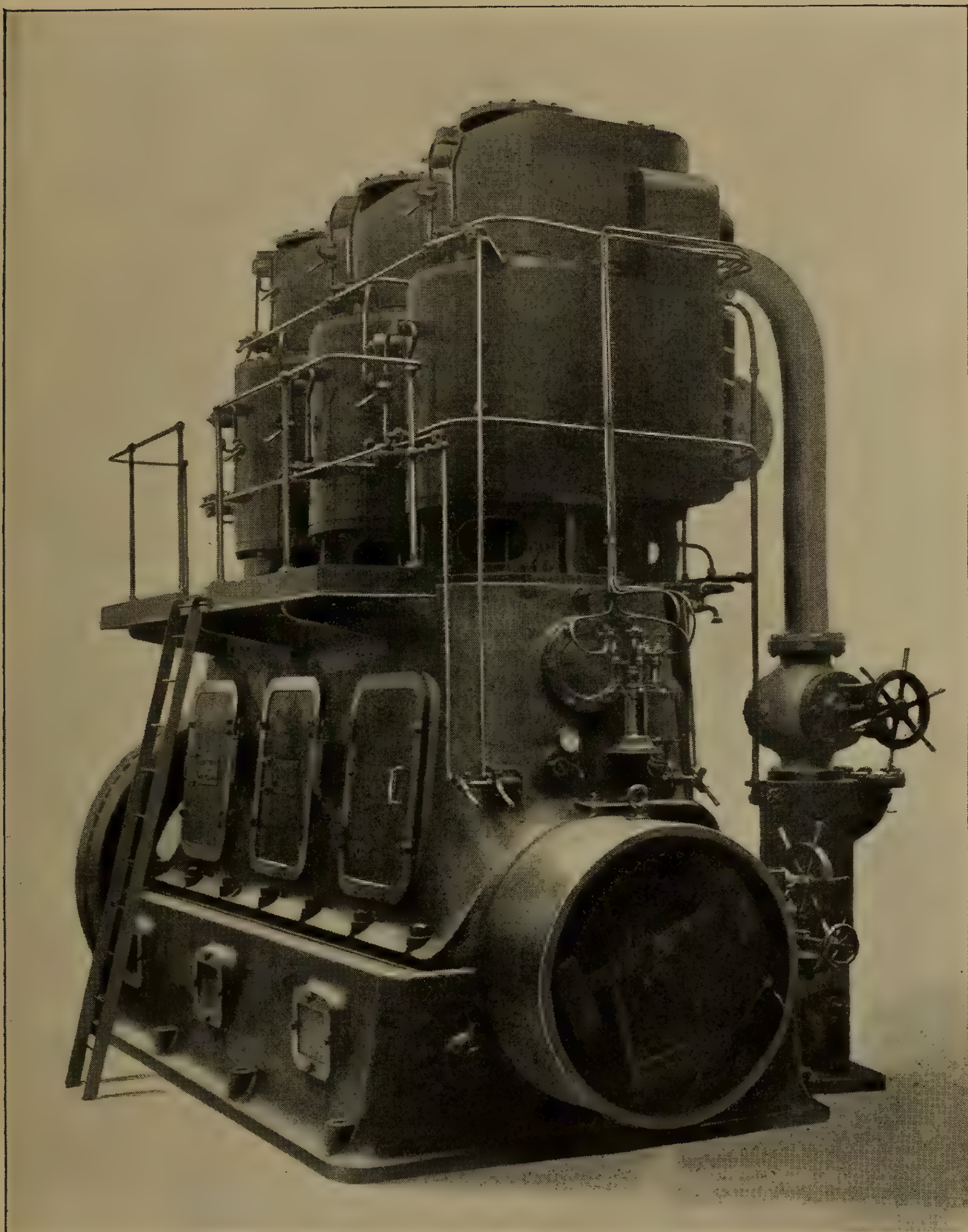


FIG. II.—THREE-CRANK, TRIPLE TANDEM ENGINE BUILT BY MESSRS. BROWETT, LINDLEY & CO., LTD., MANCHESTER

engine,—simple in design and massive in construction. No belts, chains, or toothed gearing are used, the governor being attached to the crankshaft itself and operating a double-beat equilibrium or Cornish valve in the steam pipe.

Experience has shown that no advantage accrues from the use of automatic expansion gear in engines of this class, either on the ground of economy or of efficiency; while owing to the great uniformity in the turning moment, an exceedingly sensitive governor of the simple throttling type can be employed, giving results as regards percentage of variation in speed under given fluctuations of load equal to any possible requirements.

We have seen sufficient evidence that high rates of rotation can be, and are, in practice, satisfactorily attained for long periods at a time with but little wear-and-tear, and with less attention than is commonly required in slow-speed engines of any kind. While there is thus, to say the least of it, no disadvantage from driving the reciprocating parts at very high speeds, there is a

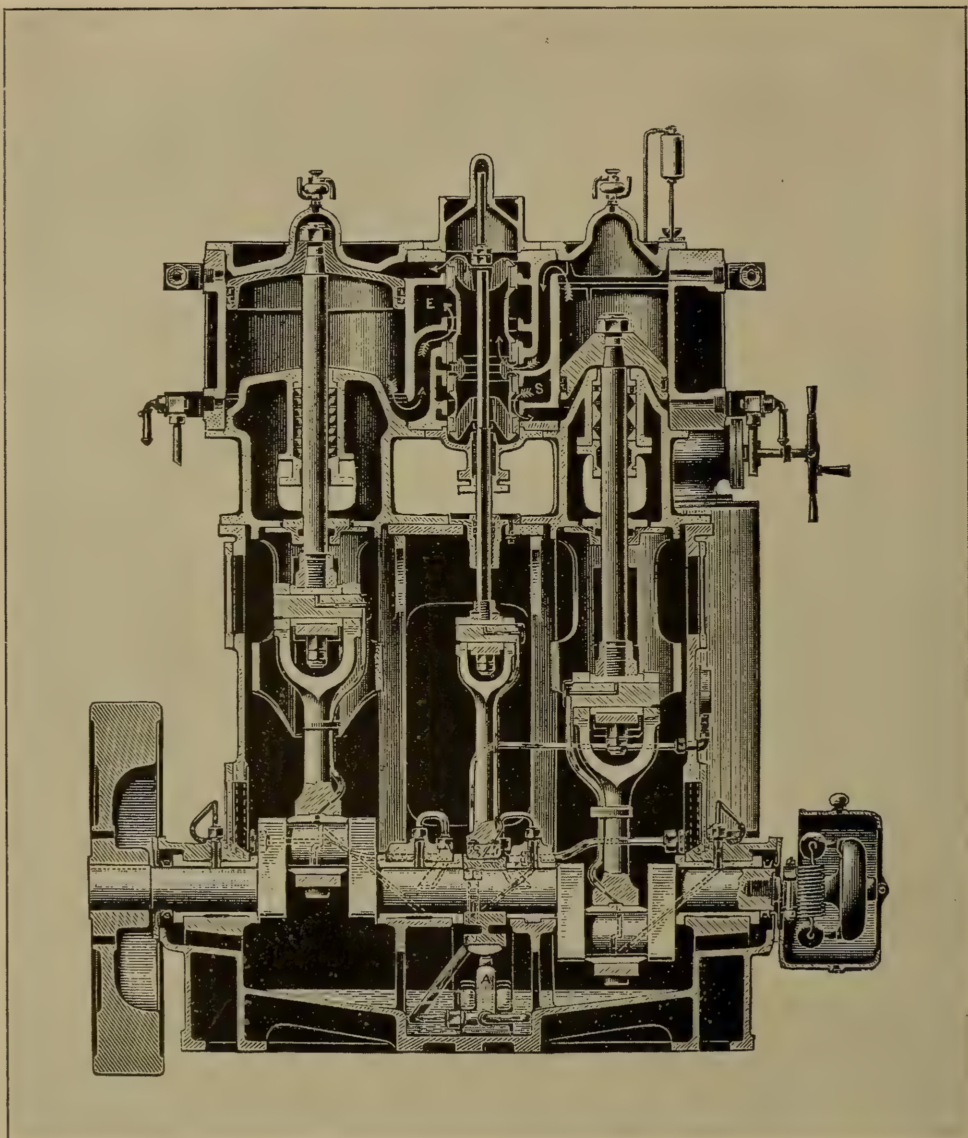


FIG. 12.—SECTION OF COMPOUND ENGINE BUILT BY MESSRS. BELLISS & MORCOM., LTD.

positive benefit in working the steam through cylinders where the alternations of steam inlet and exhaust are so rapid as to allow no time for the cylinder walls and pistons to cool down to exhaust temperatures. Repeated experiments have shown that these engines suffer too little from initial condensation to derive any benefit from steam-jacketing the cylinders. The effects of the greater clearance frequency are neutralised by compression; while the fact that a small, quick-rotation engine can be set to do the work of a large one moving at a slower speed, reduces to a minimum the external wastes arising from radiation and conduction.

On the manifest advantages of direct coupling, as compared with rope or belt connection to the dynamos, it is unnecessary to enlarge. Suffice it to say that the quick-rotation engine, in any or all of the forms illustrated in these pages, has marked out a path for itself in which, so far as present knowledge extends, it has no serious competition to fear.

We must now turn our attention to a class of engine which, save that it comes under the head of quick-rotation engines, has nothing in common with those already described,—the single-acting, constant-thrust type, of which by far the most prominent example is the Willans engine, of which a section, showing a triple-expansion engine, is

given in Fig. 15. As this celebrated engine works on a plan peculiar to itself, a short description of its mode of operation may be of service. The steam is distributed throughout by the hollow piston-rod or "trunk" *R*. It enters from the steam-chest at the top by the upper set of oblique cut-off ports, as shown by the arrows. By the movement of the line of piston valves which work inside the piston-rod (driven by the eccentric-rod shown) the steam passes into the high-pressure cylinder at the beginning of the stroke by the holes or ports shown just above the high-pressure piston. It is important to remember that this ring of ports is the only inlet to and outlet from the cylinder, and that it moves up and down with the piston. After the steam has worked expansively in the high-pressure cylinder the valve passes above the ports and opens communication from the working end of the cylinder, *i. e.*, the space above the piston, to the space below it, which is called the high-pressure receiver, but which is equally a steam-chest for the intermediate cylinder. During the up-stroke the steam is simply transferred from one side of the piston to the other; the whole cylinder, including the "working end," at that time forms part of the receiver.

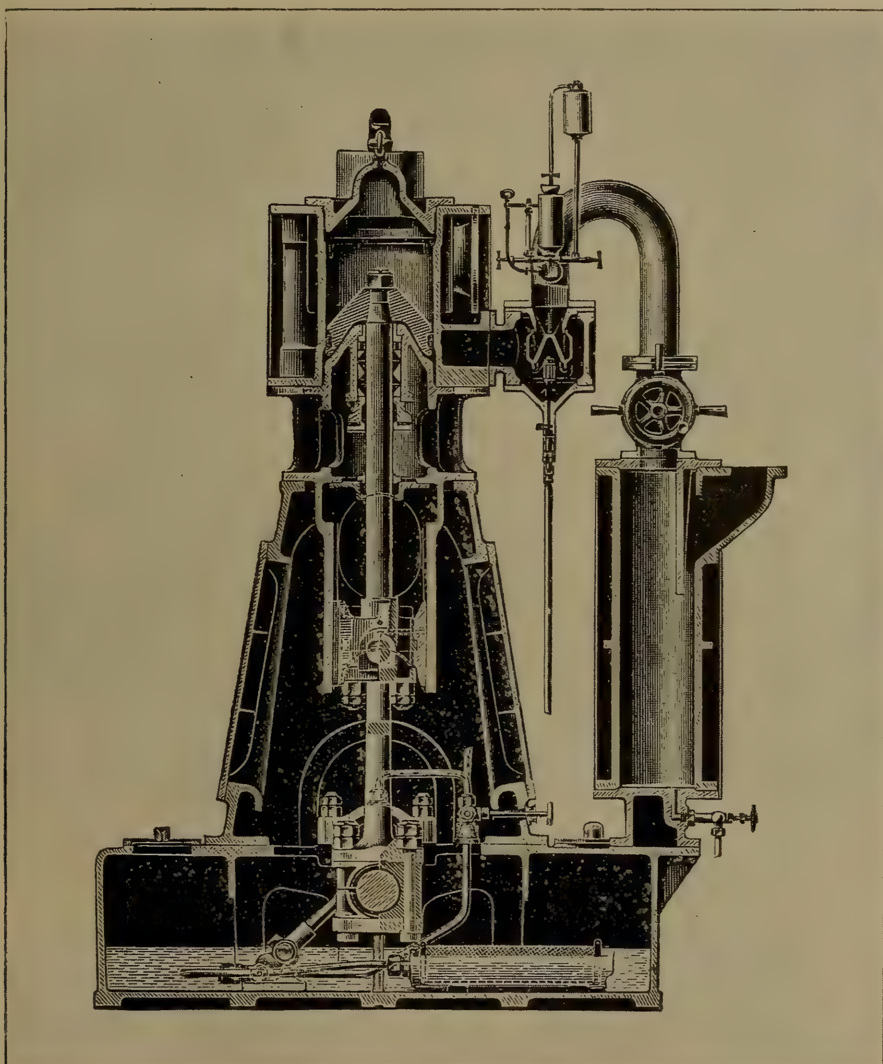


FIG. 13.—ANOTHER SECTIONAL VIEW OF THE BELLISS COMPOUND ENGINE

When the next down-stroke commences, the steam in the high-pressure receiver is passed into the intermediate cylinder. It enters the hollow piston-rod again from the receiver by the ring

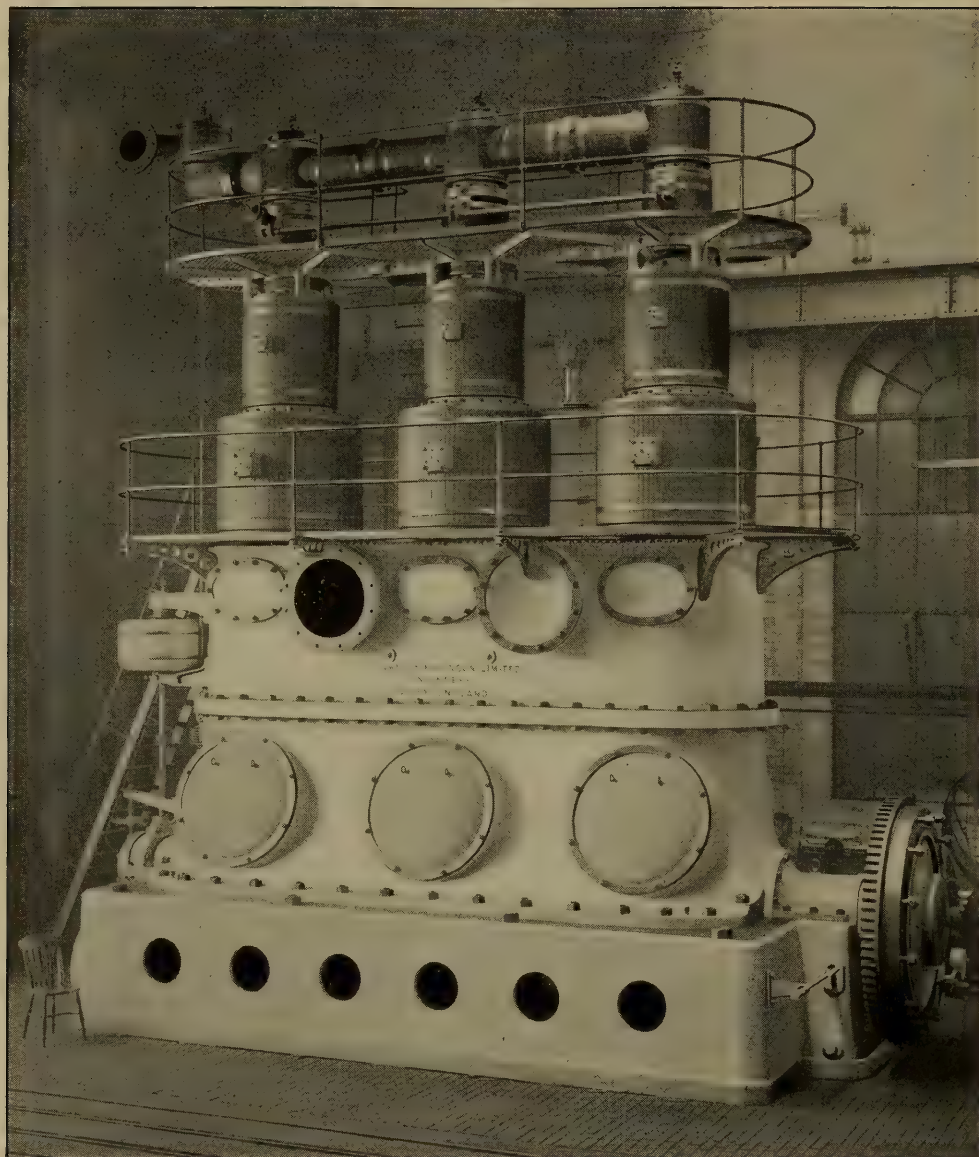


FIG. 14.—A WILLANS 2400 H. P. ENGINE AT THE PARIS EXHIBITION. BUILT BY MESSRS. WILLANS & ROBINSON, LTD., RUGBY

of short, square-headed holes shown, and passes from the piston-rod to the cylinder by the ring of ports shown just above the intermediate piston. Cut-off in this case is given by the square-headed ports passing into the gland in the intermediate cylinder cover, and so losing the supply of steam from the high-pressure receiver (*i. e.*, the intermediate steam-chest). The cycle is exactly the same as already described for the high-pressure cylinder, and at the end of the second revolution the steam fills the intermediate receiver. Thence, in the third revolution it passes into the low-pressure cylinder; and in the second, or exhaust, half of that revolution it passes from the low-pressure cylinder, *i. e.*, from its upper end to the lower end, of course, without material change of volume or pressure. It is only during the first half of the fourth revolution that it finally passes away from the "transfer chamber" to the "exhaust chamber," the latter being in permanent communication with the condenser.

The full cycle thus described is that of a triple-expansion Cornish engine. In each separate stage of the expansion the complete Cornish cycle can be traced, and it is evidenced by two separate diagrams from the upper and lower end of each cylinder. The diagram from each receiver, or from the "trans-

fer chamber,'' represents (as in every Cornish engine) work done upon the up-stroke; but it indirectly contributes to the power of the engine, for on the up-stroke the piston is *in equilibrio*, while the removal of back-pressure on the down-stroke is a virtual addition to the size of the diagram from the upper end of the cylinder. The advantage is that the total range of temperature due to each stage of expansion does not take effect in the working cylinder, but only part of it. Part of the temperature range acts in the receiver only, where it does little harm. The limitation of the temperature range in the working cylinder is, of course, a clear gain in the matter of initial condensation.

The cushioning arrangement is special to the Willans engine. The guides take the form of bored cylinders, and the crossheads are pistons without rings. The top of the guide cylinder is closed, and on the up-stroke the air in it is compressed to the extent necessary to cushion the pistons and other parts. The power stored in the air by compression on the up stroke is given out again during the immediately succeeding down-stroke without sensible loss.

The line of valves is driven by an eccentric on the crank-pin. It is necessary that the source of motion for the valves should itself move up and down with the pistons, since the ports which have to be opened and closed also move up and down.

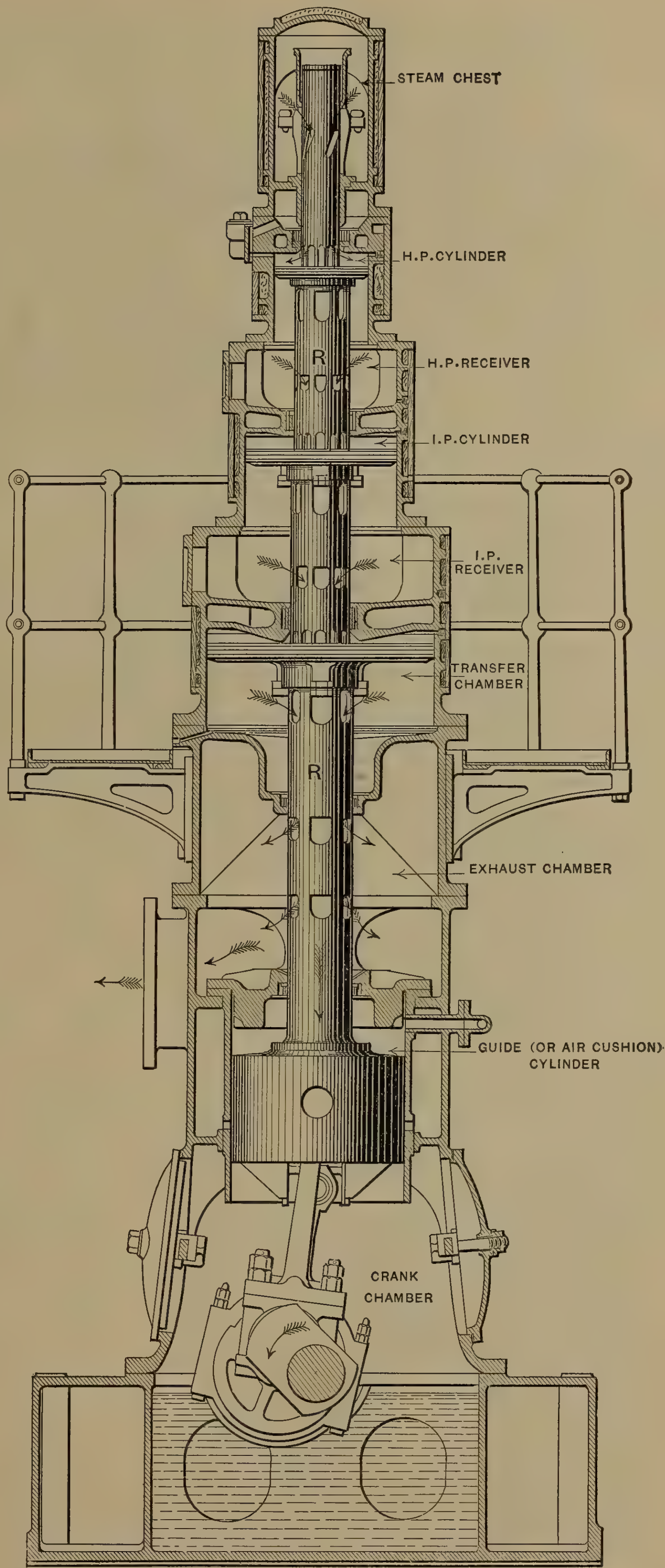


FIG. 15.—SECTION OF A TRIPLE-EXPANSION WILLANS ENGINE

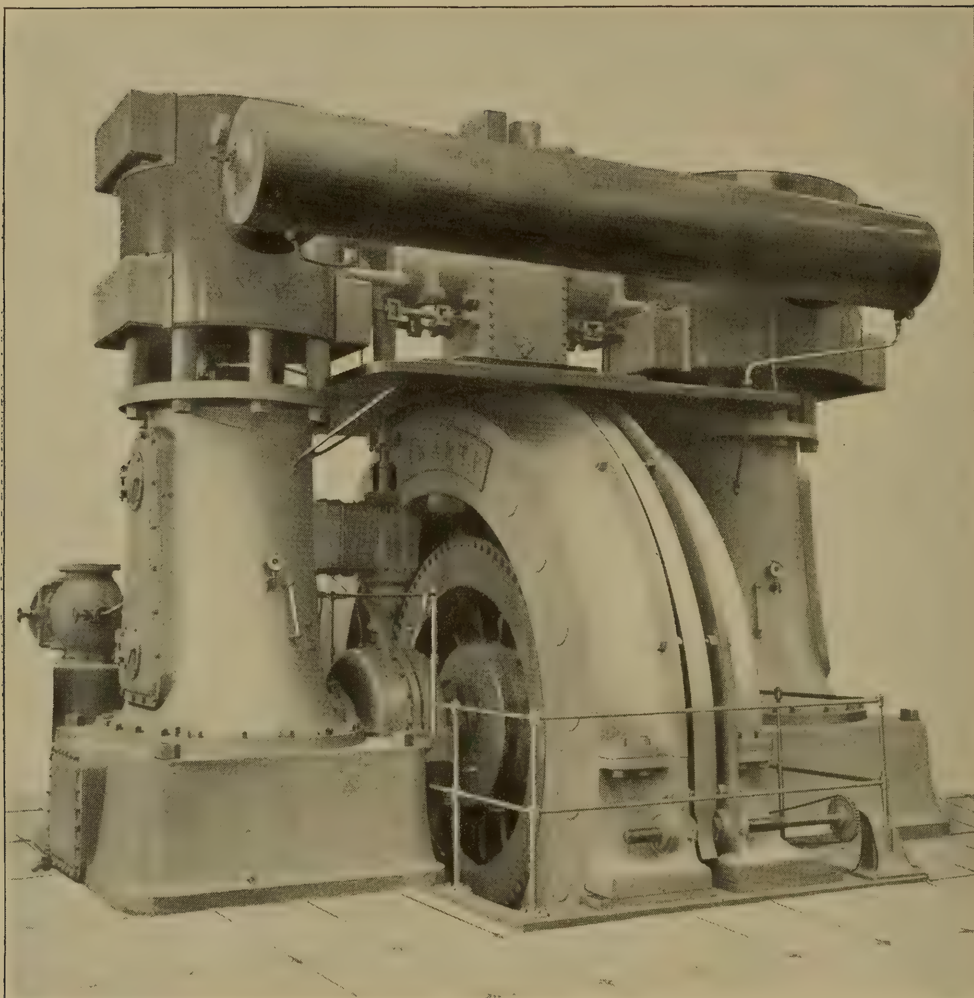


FIG. 16.—COMPOUND ENGINE BUILT BY MESSRS. FERRANTI & CO., LTD., HOLLINWOOD, MANCHESTER

There are two connecting-rods to each line of pistons, one on each side the eccentric; the eccentric rod plays between them. The cranks and all working parts, except the cylinders and valves, are lubricated by the splash of the cranks in the crank-chamber, where the lubricant usually consists of a mixture of oil and water.

The jacketed receiving bottoms, shown in Fig. 15, are now omitted, as, like all attempts to improve the Willans engine by steam-jacketing, the gain has been found to be exactly balanced by the loss through condensation in the jackets. Fig. 14 shows a 2400-H. P. Willans three-crank, triple-expansion engine driving a Siemens dynamo at the Paris Exhibition for lighting and power. The cylinders are 18⅞, 30 5-16, and 49 inches in diameter, the stroke being 27⅝ inches. The speed was 200 revolutions per minute. The crankshaft is 14½ inches in diameter, and weighs about 12 tons; the total weight of the engines, which are capable of exerting 3000 H. P. for short periods, is about 120 tons. The floor space occupied was only 31 feet by 11 feet 1 inch. The great size of this fine set of engines is effectively shown by the chair in the left hand corner of the picture.

The "Universal" steam-engine built by the Brush Electrical Engineering Company, Ltd., London, is shown in section in Fig. 17. The chief features of this steam engine are as follows:—

The extremely short steam ports and single-acting cylinders render it highly economical of steam. It has fewer working parts than any other high-speed engine that can claim approach

to it in economy. A single-crank "Universal" engine has the same number of impulses per revolution as a two-crank engine of the Willans or Belliss type. The wearing parts are very easily adjusted. It does not require a skilled mechanic to make the adjustments when required. There is only one gland to keep packed, and that one is not subjected to high-pressure steam. It is enclosed when working, but by the removal of the steel casing, which occupies only two or three minutes, the engine is made as accessible as any open engine.

The "Universal" engine is, by its construction, naturally self-draining. The indicator diagrams, at all loads, leave nothing to be desired, and show remarkable results attained with only two valves, which are both of the Corliss type. One of the two valves is controlled by the expansion governor, and has no other function but to admit steam to the high-pressure cylinder; thus the point of cut-off is varied automatically with the load to any extent without throttling the high-pressure exhaust. The pressure of the admission steam is substantially constant with any degree of cut-off within the usual working limits, and the compression at the bottom of the down-stroke,—where gravity assists inertia in opposing the reversal,—is also substantially constant, and the engine runs silently at all loads.

Another type of engine, embodying many special features, made by Messrs. S. Z. de Ferranti & Co., Ltd., of Hollinwood, near Manchester, is illustrated in Fig. 16. To obtain the economy of Corliss engines the system of four valves per cylinder has been adopted, and these valves are placed in the covers so as to minimise clearance surfaces and spaces.

The valves are of the grid type, with a very short movement, and as the valve gear is worked only at half the speed of the engine, the surface speed of the valve-faces is very low; consequently the wear and tear is low. The valves are worked direct from cams, these being so designed as to give a constant distance between the cam rollers, thus making it possible to work with fixed rollers, and making the motion quite independent of springs, and, therefore, quite positive. The cams are arranged on vertical shafts, working in a completely enclosed box, which will be seen in the illustration to stand midway between the cylinders. This box is filled with oil; consequently the whole of the valve gear works absolutely immersed in oil. This has a very important bearing on the working of the cam gears, and, further, it leaves no part of the

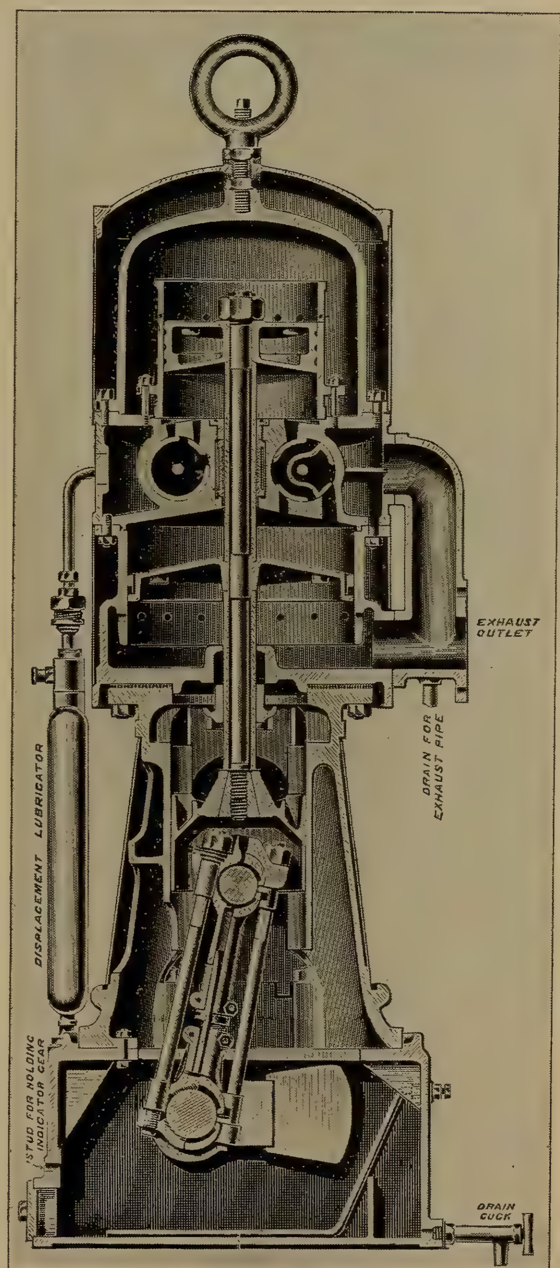


FIG. 17.—THE "UNIVERSAL" ENGINE. BUILT BY THE BRUSH ELECTRICAL ENGINEERING CO., LTD., LONDON

valve gear to be oiled by the engine attendant.

The connection between the cam and the valve is a direct one; thus there need be no joints to wear, and, as will be seen, the external valve gear is extremely simple. The cam-shafts are driven by means of cut gearing from the crankshaft, and each wheel is arranged to run in an enclosed casing containing oil, thus eliminating any question of their lubrication. The governor can be arranged either to vary the cut-off automatically, or to act on a throttle valve, in which latter case the cut-off can be made either adjustable by hand or fixed.

Turning to the main parts of the engine, these are, on the whole, of ordinary construction, similar to those usually adopted in marine practice, except that the crank-pin bearing is of the spherical type, so as to ensure equality of pressure along the pin; also the main bearing steps rest in spherical seats with the same object.

The reciprocating parts are very thoroughly enclosed, so as to prevent the slightest splash or leakage of oil. Messrs. Ferranti adopt a forced lubrication system, and make the pumps of ample capacity to give sufficient pressure after the engine has run a considerable time, and in consequence worn the bearings rather slack. This removes the necessity for frequent adjustment of bearings, which is experienced if the oil pump is small. The oil is forced from the pump through a very effective filter which is arranged in the engine bedplate; the door of the filter will be seen in the illustration. From the filter the oil passes to the various bearings from which it falls into the bedplate through a strainer into a tank below. Thence it is again pumped through the filter to the bearings. In connection with electrical work the matter of keeping oil away from the dynamo is of the utmost importance, quite apart from the point of view of cleanliness and avoidance of waste. This engine, owing to an accidental delay in furnishing the particulars, was unavoidably omitted when dealing with the class of medium-stroke, double-acting engines, to which class it, of course, belongs. The writer is pleased, however, to have the opportunity of including it in this survey of British vertical steam-engines.

FIG. I.—A 10,000 H. P. FUSE EXPLOSION

SOME POWER TRANSMISSION DIFFICULTIES

ON HIGH-TENSION ELECTRIC CIRCUITS

By I. R. Edmands

IT seems like a comparatively easy problem to transmit electrically a few thousand horse-power from one given point to another a reasonable distance away. The engineer will say, " Use step-up transformers, transmit at ten, twenty, or thirty thousand volts; step-down with transformers to the pressure desired at the place where the power is to be used, and that is all there is to be done."

This does sound simple, but to do it and give continuous service twenty-four hours per day and three hundred and sixty-five days per year has, in practice, been found exceedingly difficult, especially where great amounts of power are involved. All the preliminary experiments were done with small amounts of power, and after a while difficulties were overcome, apparatus was standardised, and fair results were obtained. When it came to larger units and more power, much apparatus which had been perfectly reliable under former conditions proved worthless. Switch-boards, with their fuses, circuit-breakers, lightning arresters, all had to be modified or redesigned.

It was remarkable how quickly some of the early switch-boards, designed for use in connection with power plants of large capacity, would have the marble reduced to lime and switches and instruments to vapourised copper by the improper working of a fuse or circuit-breaker. Even at the present time switch-boards and their accessories are considered the greatest factors of uncertainty in a transmission system.

Some of the experiments made, with the view to perfecting fuses and other apparatus for these uses, were extremely interesting, both from scientific and spectacular standpoints. The illustration shown above is a reproduction of a photograph taken during the " blowing " of a specially constructed fuse of 1000 ampères capacity on a 2000-volt

circuit, backed by a generator capacity of 10,000 horse-power. Using the term "blowing" the fuse is altogether too tame an expression for these conditions. It would better be called "exploding," as a great noise is made and a fine fire display is produced.

High - tension, alternating - current fuses have, to a large extent, been superseded by varying forms of circuit-breakers, some of which are absolutely reliable. One of the most important objections to the latter was that they would break the circuit on a momentary increase in current, which occasionally happened when there was no reason to shut off the power. Fuses were well adapted for these overloads lasting only a few seconds, for it takes an appreciable time for them to heat to the melting point; but the trouble comes when they do blow, as they have a decided tendency to not only destroy themselves, but everything in their vicinity. This led to a design of circuit-breaker with a time attachment which is adjustable, so that when an overload occurs the circuit will not be opened until after the lapse of a certain number of seconds, and if the current drops again before this set time is reached the breaker will not open. With this class of protective devices on a large system continuous service is much facilitated. The breakers nearest to, or at, the power house should be set for the longest time, say, six seconds; those on the branch lines should be set for four seconds; and those connecting other lines or apparatus for two seconds. This arrangement insures the continuance of the main line unless the trouble is with itself. One of this type of breakers, without the time attachment, is shown in Fig. 4, in the act of opening a high-tension circuit.

FIG. 2.—THE RELATIVE CONSPICUOUSNESS OF WHITE AND BROWN INSULATORS ON TWO DIFFERENT TRANSMISSION LINES

Next in importance to the overload devices of a transmission line comes those that protect the apparatus at its ends from lightning. Most of the lightning arresters built up to the present time have had one of two faults. Either the air gaps between their cylinders or balls were so great that they were no protection to the apparatus, or the gaps were so short that current from the line would follow the lightning discharge and destroy the arrester for future use. This last fault has been overcome by inserting resistance between the series of gaps and the ground sufficient to limit the current which will follow the lightning discharge to such a small amount that it cannot harm the arrester. Many tests have been made to determine the best forms and most effective ways to protect against lightning, but it is so difficult to reproduce ordinary conditions of lightning artificially that improvement in this line is slow, and is usually the result of actual experience. Figs. 3 and 5 show some attempts to test the above-mentioned form of arresters. The test is started by a miniature lightning discharge made by a Roentgen ray set, and the illustrations show the current discharges which follow. With tests of this nature the camera plays an important part, for the brilliancy and noise of the discharge leave the observer in a dazed and undecided state as to what actually hap-

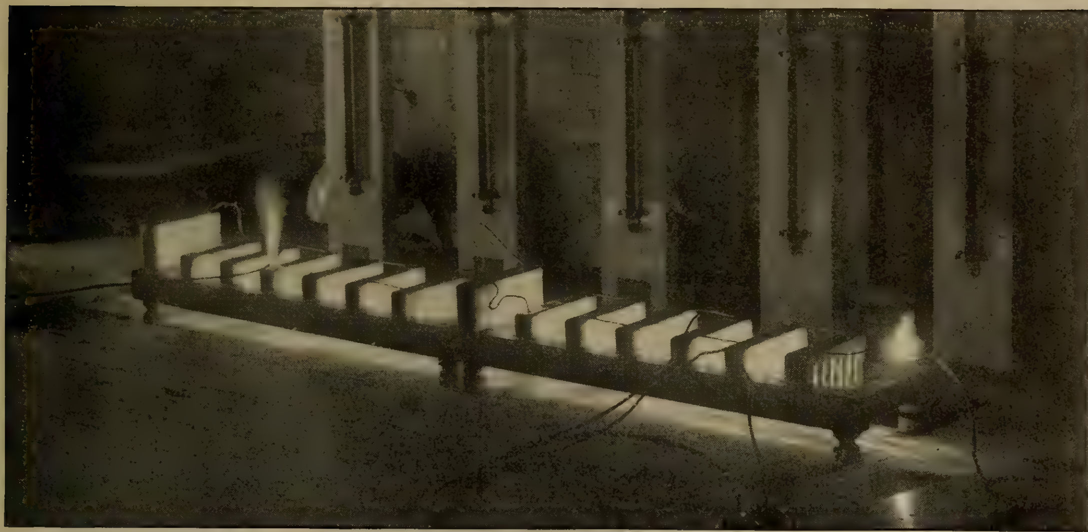


FIG. 3.—EFFECTS OF ARTIFICIAL LIGHTNING DISCHARGES

pened; but the photograph gives an exact reproduction of what occurred, and can be studied at leisure.

The transmission line, made of bare conductors stretched at the top of poles and supported on insulators, is in itself quite simple; but when there are thirty or more miles of it, with many thousands of insulators, any two of which being defective, may cause trouble, it is easy to understand the chance for interruption of service. There are a thousand other things to make trouble that no one would ever imagine until they have actually been experienced. Sometimes trees that are apparently a safe distance from the lines are blown on to it during a storm, either causing a short circuit or tearing down the wires.

The large, white porcelain insulators so commonly used are another source of trouble. Being so white, they are very conspicuous, and are, therefore, irresistible to the marksman, who shoots them off, little knowing of, or caring for, the weary hours of tramping and inspection necessary to patrol perhaps the whole length of the line to locate the fault which is shown by the ground detector at the station. After the broken insulator is found, come the care and danger necessary to replace it without interrupting the service. This, although a risky operation, is often done. Coloured insulators can nowbe obtained, which overcome the temptation to the marksman. Fig. 2 shows two transmission lines, one equipped with white and the other with brown porcelain insulators.

Probably the most exasperating cause of trouble with bare overhead lines is the small boy with a piece of hay-bale wire which he tosses up to see the fireworks. The great display is liable to

FIG. 4.—A CIRCUIT BREAKER OPENING ON A HIGH-TENSION LINE

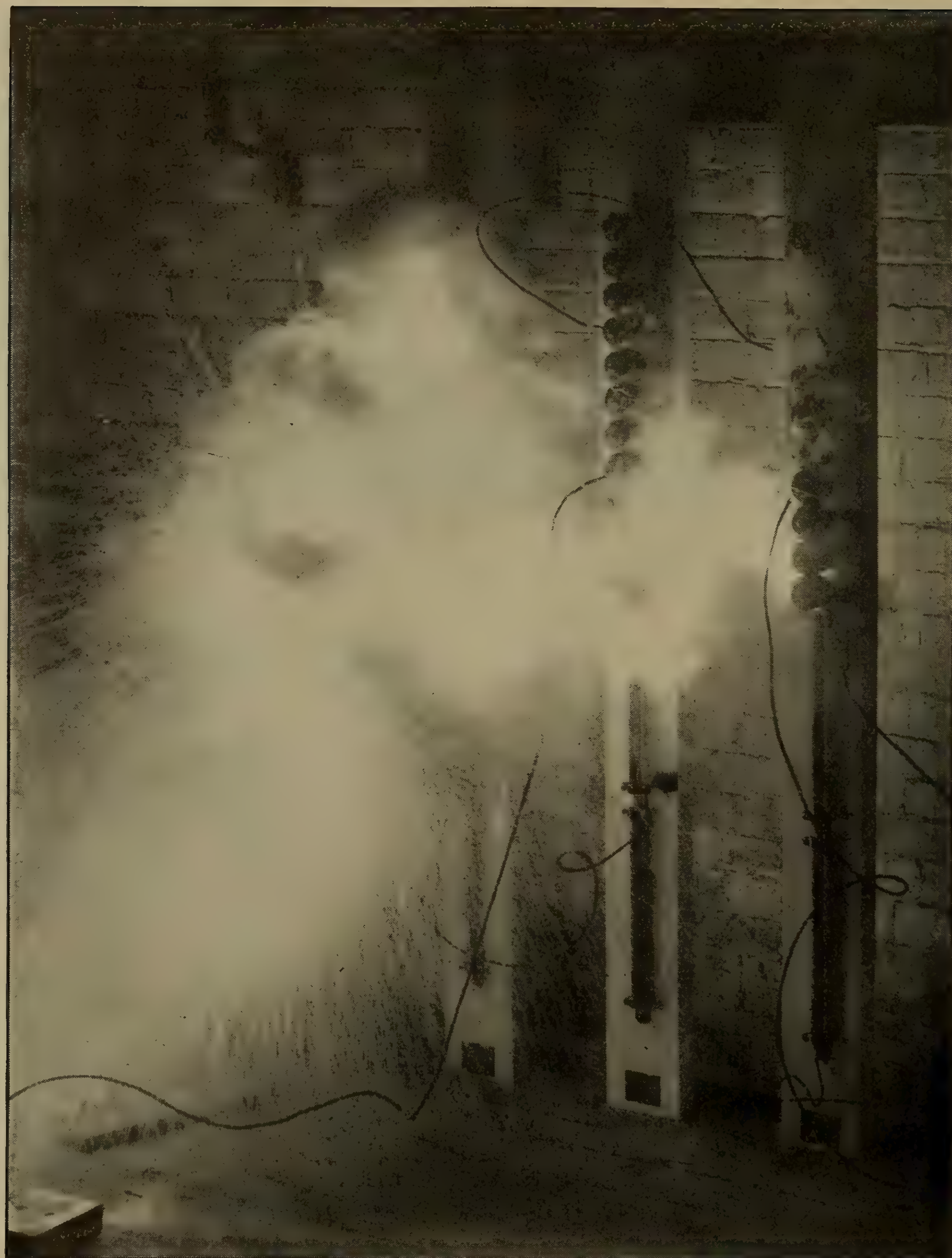


FIG. 5.—ANOTHER ARTIFICIAL LIGHTNING DISCHARGE EFFECT

strike terror to his heart and impress him with the enormity of his crime, so that he will not do it again; but it is possible for an apparently infinite number of boys with the desire to see fire to live within the neighbourhood of a 30-mile line, and it is difficult to locate a boy after his desire has been satisfied.

After once getting started, an arc, under proper conditions, will hold across a surprisingly long distance. A number of instances are recorded of an arc holding between conductors eighteen inches apart on a 10,000-volt line for a length of time sufficient to completely burn off a 350,000-circular mil. cable. A peculiar instance was once observed of an arc, after being started between conductors, continuing to hold while the wind blew it along the line, producing an effect similar to a meteor travelling parallel to the earth's surface. The distance between the conductors on this line was eighteen inches, but this was changed to thirty-six inches to overcome this and other troubles.

An instance of a remarkably long arc holding occurred recently on a circuit-

breaker panel connected to a 10,000-volt circuit. The breaker was of the long-arm type, that would simply open the circuit by making a long break. The arms were separated by barriers projecting 24 inches from the face of the panel. As the arms came out in the act of opening the circuit, the arcs became connected outside of the barriers, and held long enough to completely destroy the panel.

The majority of transmission lines installed up to the present time have been overhead lines, with bare conductors, supported on insulators at the top of poles; but under some circumstances, such as running through thickly populated districts, or where continuous operation is essential, underground lines meet the conditions better. The underground system offers some advantages in that it is out of sight and less liable to malicious treatment. Climatic conditions do not affect it, and it thus escapes entirely one of the most serious troubles with overhead lines, namely, lightning. Interruptions from falling trees, adjacent fires, storms, marksmen, and the small boy all fade out of sight when the conductors are below the surface.

There are, however, some drawbacks to this system also, and placing conductors underground does not entirely eliminate troubles from external sources. There are many instances, especially in cities where the labourer digging a trench for water, gas, or sewer pipes, drives a pick or bar through a conduit and into a cable, destroying its insulation. But it is seldom that a well-protected conduit is disturbed, as it becomes obvious, even to a very thick-headed individual, after picking away at well-seasoned concrete for awhile, that it was probably put there to stay, and for some purpose. The one great chance for interruption in the underground system is the breaking-down of the insulation on the conductor, and although excellent cables are made and every known precaution is taken to make them perfect, faults will occasionally develop, and sometimes are most difficult to locate, especially on very long lines. These should be divided into comparatively short sections by switches; then, in case of trouble, the defective section can be easily located and the fault found much more quickly.

Electrolysis is responsible for much cable trouble, destroying the lead covering, exposing the insulation, and thus leading to rapid deterioration. Electrolysis can be guarded against, and, if proper precautions are taken, it can be almost eliminated.

Static discharges on long cables, or

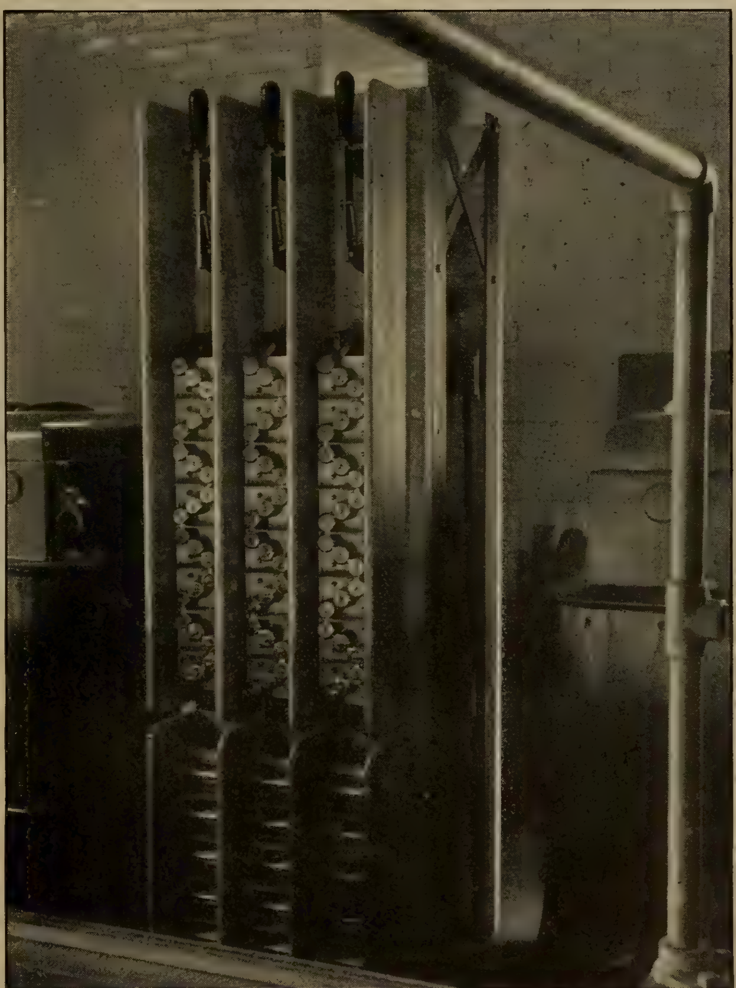


FIG. 6.—A DISCHARGE PANEL ON A 12,000-VOLT UNDERGROUND LINE

those of high capacity, are often the cause of trouble that is thought to be due to defective insulation, and all such lines should be provided with devices capable of conducting away the discharge. Even on lines only a few miles long, discharges of this nature, although very slight and scarcely noticeable, will, in time, give trouble. A common place for this to occur is at the cable ends at the point where the lead sheathing stops, discharging between the end of the lead and the conductor, resulting finally in the destruction of the insulation.

Fig. 6 shows one of a set of discharge panels used at the ends of a 10-mile, 12,000-volt, paper-insulated underground line. The arrester was discharging as the photograph was taken, as can be seen by the small, bright spots at the gaps between the balls. These discharge panels are similar to those built for lightning protection, and are composed of air gaps between brass cylinders or balls, with a resistance connected between the gaps and the ground to prevent a damaging current from following the static discharge.

Ground detectors are a most essential feature of any kind of electric transmission line, for by their use a single ground can be discovered before any interruption to the service occurs, and immediate steps can be taken for making repairs. With the knowledge gained by the past years of experience, it can now be truly said that by using the best advice for designing, the most careful work in constructing, and great diligence in maintenance, power transmission can be made reliable for practically continuous operation.

AERIAL ELECTRIC TRACTION

By Alton D. Adams

ELECTRIC railways have materially reduced the costs of transportation on surface and elevated railways, but there remain many cases where ordinary electric traction systems are not available, as at mines, where transportation may be desired over deep and comparatively narrow gullies or valleys, at large excavations and embankments for engineering works, for lumbering operations in swamps, and the movement of canal boats. In many instances under the examples cited no rigid rail structure is commercially practicable, and the most that can be provided is a flexible cable system. Such cables are used for mechanically operated transportation systems, but these are subject to disadvantages in both application and operation.

The transportation in most mechanical aerial systems is necessarily accomplished by actual movement of one cable along with the loads, the only exception being the case where loads travel exclusively in one direction and by gravity. But this last plan is available only under special conditions. Mechanical aerial conveyors may consist of one or more endless cables with loose or fixed buckets; of one or more pairs of cables, one fixed as a supporting cable, the other endless and moving for traction; or of one fixed supporting cable and a moving cable that alternates in its direction of travel. Those systems that use a number of cars spaced along the cable must give to all the same rate of motion. Where separate cables are used for support and the work of traction all the cars must still have nearly the same rate of motion.

In all these systems the weight of, and the work expended to, move the traction cables are large, compared with the weight of, and work expended on, the materials transported. A necessary result of the large fixed weight in moving parts is low efficiencies for aerial mechanical conveying systems. As cables grow longer and their courses include material changes in horizontal directions, the difficulties of operation increase and the efficiencies grow less.

Ten years ago quite a number of extensive cable systems were operating street cars in the United States. Now nearly if not all of these street railway cables have been replaced by electric traction systems. The street railway cable, suspended in a conduit beneath the rails, is subject to similar conditions as to wear and power consumption, in many respects, as the aerial cable for freight transmission. A high rate of depreciation and a low efficiency in the former have been the main factors that operated to replace cable with electric railways, and the same causes may be expected to show a similar tendency in extended systems of aerial transportation.

Electric traction on aerial cables differs from the mechanical systems in complete independence of any number of moving units, the stationary condition of all cables, limitation of the energy expended to that for loads actually in motion at any one time, freedom as to length and directions of the lines, a lower rate of depreciation, and a higher efficiency. On electric aerial cable lines, as on surface railways, the tractive effort is exerted by motors mounted on the moving vehicles. One large and one small cable, or a large cable and a conducting line, are necessary for each direction of transportation at the same time, according to the method employed to secure tractive effort. The motor, mounted on a suitable carriage, is suspended from the main cable. In

one plan the friction between the cable and the wheels of the motor carriage is relied on to give sufficient traction. This system is best suited to those cases where the direction of the cable is nearly horizontal and the load is suspended from the motor carriage so that its weight increases the friction at the cable. In other cases the grip of the wheels of the motor carriage on its main supporting cable is increased by clamping parts that permit the pressure between the wheels and cable to be adjusted. Where the tractive effort is obtained by contact with the carrying cable, the other cable or wire is required only for electric conducting purposes, is subject to slight mechanical strains, and may be of small size. One terminal of the dynamo or electrical supply system is connected to the main cable and the other terminal to the conducting wire. The path of the electric current is then preferably along the conducting wire to the motor, and thence through the frame of the carriage to the main cable. It is better to have the electric current flow in the direction just indicated and then to connect the main cable to earth at intervals, or at least at its ends, because the insulation of a cable subject to very heavy strains is a difficult matter. Such arrangement of the conducting wire and main cable corresponds to that of the trolley wire and rails in electric street railway practice.

A variation from the plan just named provides two connecting wires to make connections between the dynamo and the cable motors, and sends no current through the main cable. Another system of electric cable traction provides a main cable to carry the motor carriage and its load, but obtains the tractive effort by means of another cable. For this purpose the traction cable passes around a sheave on the carriage, actuated by the motor, and the rotation of the sheave pulls the carriage along by winding cable on to the sheave at one side as fast as it winds off at the other. The tractive effort here is obviously due to the friction of the cable on the sheave, and may be regarded as limited only by the power of the motor. This last named system has proved very effective where cables must be erected at steep grades, and where the desired work is accomplished by a pulling effort approximately parallel with the cables, as in towing canal boats.

Where the smaller cable is used to secure the tractive effort, its insulation is a very difficult matter, and the more usual practice is to insulate the large carrying cable. Much trouble has been met in the insulation of these large cables under heavy strain, and a better practice seems to be to provide an independent conducting line for the positive side of the electric circuit, and then use both the traction and the carrying cables as a common return. The electric motor carriage hangs beneath the main cable, as usually arranged, the weight being sustained on small wheels or rollers.

When traction is obtained through these contacts with the main cable the motor is connected by gearing, preferably single-reduction, to the rollers that support the carriage. If an independent cable be used for traction, the electric motor is connected by gearing to the sheaves or other devices that grip this cable.

The efficiency of electric cable traction, that is, the ratio of the product of the pull and travel of the motor carriage to the energy absorbed by the motor, depends on several factors. These are mainly the efficiency of the motor, of the gearing, and of the rolling contacts on the cable. Allowing, as may fairly be done, efficiencies of 85, 90, and 90 per cent. for these respective parts, their combined efficiency is 69 per cent.,—a much higher figure than can be hoped for in most conditions for aerial traction on extensive mechanical systems.

Most, if not all, electric cable systems for traction thus far put into operation have been supplied with direct current. It seems probable that the direct-current motor will hold its place indefinitely for aerial as well as surface traction, because of its superior capacity for speed regulation. The voltage at which energy is usually supplied for traction on cable systems is 250 or 500, the latter being more in favour on extensive

lines. Most installations of this kind in the past have been operated by energy direct from a dynamo of the required voltage near one part of the cable line. The distribution of energy over large areas by alternating systems, and its transformation through rotary converters to the direct-current form, make it entirely practicable to supply electric cable systems of traction from such a source.

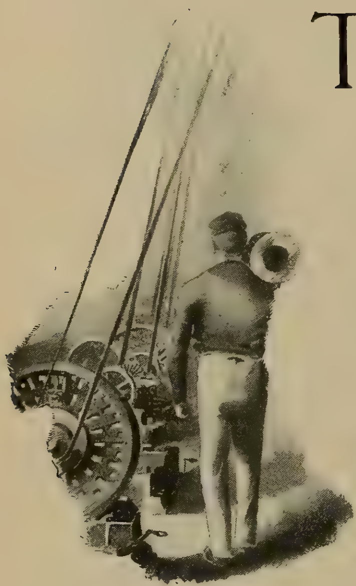
As all cables are stationary, and each moving element carries its own motor in an aerial electric traction system, any motor carriage and its load may be moved in either direction on the cable so long as it does not encounter another carriage. This condition corresponds to that of an electric car on a single line of railway. The property of independent motion for each motor carriage on a cable is especially serviceable in those cases where a long line requires a variety of work on its different parts, as on heavy engineering construction. Each carriage may be provided with hoisting gear, operated by the same motor that does traction work, so as to pick up its own loads. As each motor is started, stopped, and regulated in speed independently of all others, it must obviously have individual attention. For most classes of work the only available place for the operator of the motor is on its carriage, since he would be able to reach it in no other position. This does not imply too large an item for motor operators in the cost of transportation, because a single motor carriage can haul very large loads. The load may all be suspended beneath the carriage, or, if its nature so requires, may be divided between any desired number of receptacles that hang from the cable and are hauled by the motor. Speed regulation of motors on cables presents no serious difficulty, and is accomplished in one of the usual ways, such as by rheostat or changes in the existing power of magnet windings.

Electric cable traction lines may have any required length and as many changes in direction as desired without material effect on the difficulty or efficiency of operation. The only increase of lost energy on a long electric line is the small one due to the extra resistance of the conductors. Except as to the cost of motors and their carriages, which varies directly with their number, the system for aerial electric traction is less expensive than that for mechanical traction of equal capacity. This arises from the structural differences that must exist with a fixed, compared with those for a moving, cable. Each electric motor on a cable consumes energy only when it is at work, and the efficiency of the system is nearly independent of the total loads.

This condition as to efficiency is in strong and favourable contrast with that of the moving cable as a large and constant load. In the matter of depreciation and wear the system of mechanical traction by cables is at a decided disadvantage with the electric. In logging swamps, where no roads could be built, in quarries, from the mouths of mines to surface transportation points, for coal handling, dam building, and towage on canals, aerial electric traction has already demonstrated its advantages. When canal boats are to be towed, the best place for the motor operator and the regulating mechanism seems to be on each boat, as he is then free for other work during most of the time. Where the distances of transportation are quite short and the loads are uniformly at a maximum, the moving cable probably retains the advantage. As aerial systems, however, extend, change in direction, and vary in the amount and frequency of loads, the electric motor carriage is most desirable.

REDUCING THE COST OF MACHINE WORK

By W. D. Forbes



THERE are to-day few more interesting subjects than that suggested by the question, — In what direction may we look for a reduction in cost of machine work during the coming century? It is interesting not only as an engineering, but as a commercial, problem, and its settlement will materially affect every competitor in the world's markets.

It is beyond question that increased outputs are far more likely to come to pass in the engineering establishments of the United States than elsewhere, because wages are higher and individual value is what determines the amount of wages paid each workman, that is, speaking generally; therefore, ambition is not curbed, and worth can be safely counted on to receive its reward. This condition encourages men to think, in the direction of increased output, resulting oftentimes in great labour-saving designs being not only suggested, but entirely carried out, by workmen. The United States patent system encourages this greatly. It is thus fair to argue that more is obtained in the United States from machine tools than in any other country, and that, with the above conditions, a still greater output is to be expected as time goes on.

But the question of future output must be decided either by an increase from the shop tools now in use or by a change in the tools themselves. It is natural to consider first the possibilities of the present tools. In the writer's opinion, the large majority of working tools now in use are not made to give more than 75 per cent. of their reasonable possible output. This arises from two causes,—one, the indifference of the workman; the other, the system on which the work is given him.

It is often argued that machinists cannot be made to do more work than is now generally done by them in a given number of hours. This the writer denies. Make it an object for them to do more work and it will be done. This, then, argues that the present output is capable of increase if the workman is willing and is properly handled. But men in shops are like all the rest of the world; their personal inclinations and wants largely decide what they will earn, and the large percentage of them will not earn more than is required to satisfy their momentary wants. We all know that anything which is erratic, be it machine or man, is of little value, and men who will give a large output one week and very little the next upset all calculations. It is, therefore, plain that a way must be found to make a man desire to turn out a large and steady amount of work. That it can be done is not a question; but just how it may be best accomplished will depend almost entirely on surroundings.

But it can be well done only on the line of making a certain output necessary from a man in order that he may hold his job, and his gain must be in hard cash, not the advantage of living in a model house, or having the privilege of attending a fine course of lectures, or an insurance benefit, or anything else which is not tangible. Utopian ideas of parental care of workmen that have been tried many times in various countries have attracted the writer greatly, but he has come to the conclusion that

they do not accomplish the desired ends at anything like a fair expenditure of capital and energy, and in no case has the writer been able to find any evidence that better or more work is obtained by such care, or that it is obtained more cheaply. On the other hand, he has positive proof that an actual cash gain per day or week does cheapen work by increasing the output. Admitting that individual gain will tend to produce increased efficiency, the question may be asked, Is there no other way to accomplish this? This is answered in the affirmative. The desired result can be accomplished by keeping the belt on the tight pulley, or, in other words, by a continuous run, as it must be recognised that the loose pulley is not a producer.

At present the general system is to allow machine tools to be idle fourteen hours out of the twenty-four hours of a day; in other words, seven-twelfths of the possible output of a tool are thrown away or wasted. In speaking of the system of continuous runs the writer wishes it understood that this can be considered only in a manufactory, as he sees no practical way to make it answer in what is called a "jobbing shop." Most machine shop operations can be done as well at night as during the day; in fact, with the exception of hardening and drawing steel, and perhaps comparing very fine measurements, the writer knows of no operations which cannot be as well done.

To undertake the continuous working of a manufacturing plant will demand the most careful thought and prearrangement in order to make a success of the system, and no two establishments can be conducted on exactly the same lines, circumstances altering each case; but the writer wants to make the strongest possible assertion that it can be made a success, provided the fact is remembered that in making a continuous run a much better return on the investment will result, and part of this gain should be given to the men in wages, as in so doing their good-will is certain to be obtained. They will see the advantage which will result to them from an advance in pay and shorter hours, and there is nothing else which will, at all times, so appeal to them. But should continuous runs be tried without this main idea of shorter hours and better pay, it is difficult to believe that success can be achieved. It is, of course, understood that there are difficulties to encounter in keeping machine tools practically at work night and day. The fixing of responsibility is a serious question, both as to work and to condition of tools; but there is nothing insurmountable to be overcome.

As to improvements which can be hoped for in metal-cutting tools, there is, of course, much yet to be gained; but the lasting qualities of the tools must be very much improved, or new forms must be found which will hold their cutting edges better before a very decided gain can be seen. There is some hope that jewel points may make a very decided change in output, and they are being used to advantage now; but, as far as the writer knows, they are only for light work of a very fine class, —in fact, for removing ounces, not pounds. There are special tools giving an output which, when compared with what we call standard tools, show very great results, but these "specials" are as yet for comparatively small articles in which there is considerable latitude as to size. The writer knows that very great accuracy is claimed by special tool builders, and he has seen some very fair work, all things considered, from such tools, but only when they were new and in the hands of an expert, and not under steady, everyday handling and men.

It is the writer's belief that the greatest change will take place, not in metal-cutting tools, but by giving the tools less to do; in other words, there is little doubt that we to-day buy immense amounts of steel and iron in which are embedded the forms we want, and the art of a machinist is to remove just the unwanted metal, leaving the finished piece, no more and no less. It is in this that the greatest loss of time occurs. The writer believes that the foundry can make a very large percentage of the fin-

ished work, and he sees strong evidence of it even now. Take, for instance, the piece illustrated in Fig. 1. The metal used for this is about as hard and strong as cast iron, and the holes, which are quite small, are all cast and are as close to gauge as any ordinary drilled hole. Referring to Fig. 2, it will be seen that screw threads also are practical in foundry work. These surfaces, as produced directly in the mould, are perfect enough for many purposes even where considerable accuracy is demanded. As far as this style of casting is carried now, only comparatively small articles are made, but the only thing that stands in the way of large pieces being equally well made is the cost of the mould. The cuts represent work done by the H. H. Franklin Mfg. Co., of Syracuse, New York, U. S. A.

The foundry is already doing finished work in a most satisfactory manner, as, for instance, in turning out pump cylinder heads which require no machine work at all, being quite ready to put on, when cleaned, and some very large marine engine cylinder heads are now cast on which no machine work whatever will be put, the disadvantage of radiation arising from the rougher cast surfaces being offset by the use of special filler. The writer finds that in this case a gain is shown of not less than 50 per cent. after taking into account the increased cost of pattern and flasks, without the slightest detriment to the proper working of the engine.

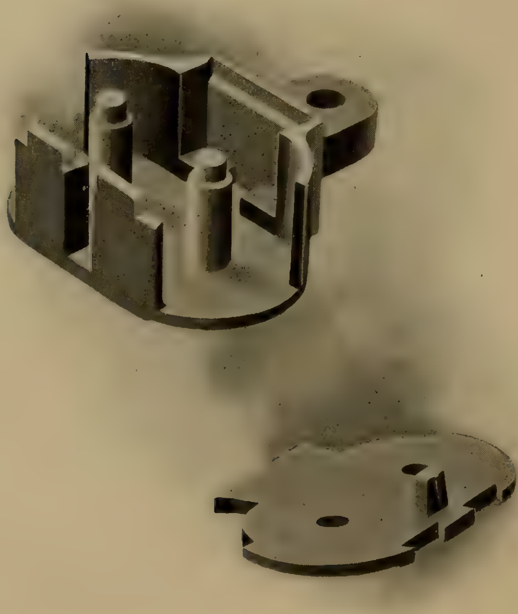


FIG. 1.—A CASTING WITHOUT MACHINE WORK

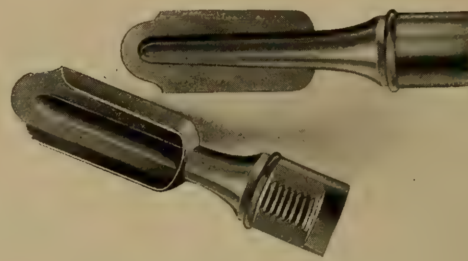


FIG. 2.—CAST SCREW THREADS

Of course, the general tendency is to produce work by special machines, and it is the writer's firm belief that this will go on until but one thing of one quality and one size shall be made by any one person or firm; that, before very long, a telegram which now would have to be worded as follows:—"Ship one 18-inch pulley, 10-inch face, 1 15-16-inch bore flat," will be simply the words:—"Ship one," as Brown & Co., say, will be the only makers of the pulley wanted, Jones & Co. making only 20-inch pulleys, 10-inch face, 1 15-16-inch bore flat, and these pulleys will never see any machine, but will come from the mould in perfectly finished shape, even to being balanced. This is, of course, supposing that pulleys will be used much longer for any purpose. The present standard tool forms will, it is fair to presume, be very much modified, with a view to do more expeditious work, but with less range. The first cost of such tools being less, will enable the manufacturer to have a larger number for the same investment. This tendency to lessen the cost of machine tools is noticeable in many tools now supplied. For instance, in a well-known milling machine the universal joints used to be highly fin-

ished pieces of work; to-day they are simply drop-forgings, nicely painted. This idea will go on, and the scraping craze on some tools will no longer be indulged in, nor will the slightest finish be put on any part except where it adds to the value of a working part or assists in setting work.

MOYORO BAY, IN THE ISLAND OF ETROFU. A VIEW OF THE SULPHUR HILLS

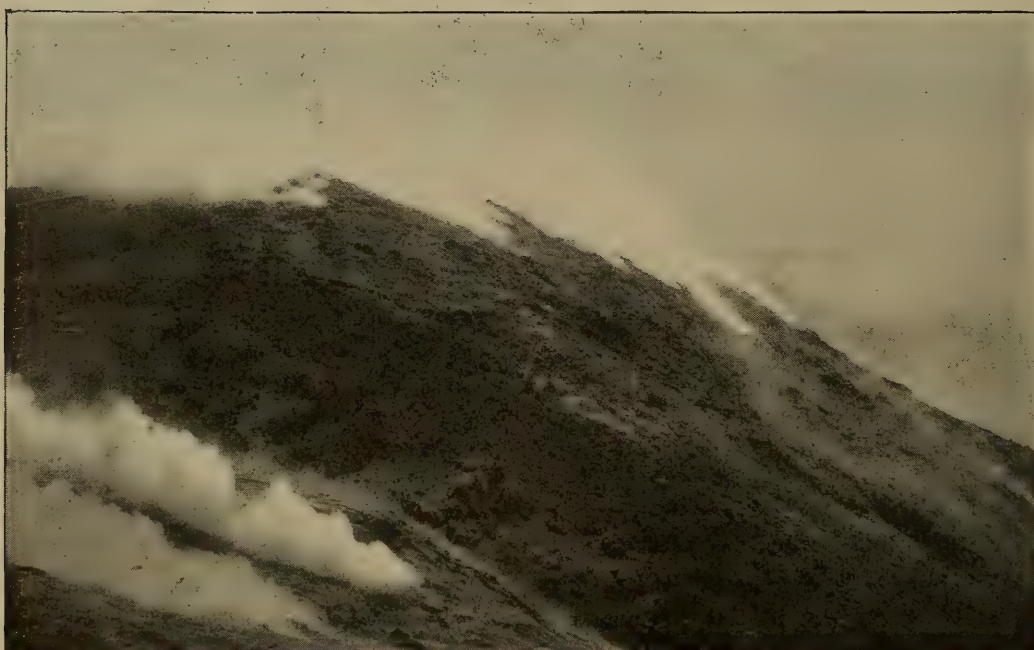
SULPHUR MINING IN THE NORTH PACIFIC

By William H. Crawford, Jr.

On the upper end of a little island in the North Pacific Ocean, half way between the most northern point of the mainland of Japan and the peninsula of Kamchatka, there is to be found an interesting example of engineering skill and perseverance, of which very little is known at the present time. In the early part of May, 1898, some Japanese prospectors approached the representatives of an American firm at Yokohama with a proposition that they unite in the erection and operation of a large plant for mining and refining sulphur. These men held the government grants for several square miles of land on the northern end of the island of Etrofu, where are located what are now supposed to be the most valuable deposits of sulphur in the world.

There are there three volcanic mountains, about 2800 feet in height, of almost pure sulphur, and the vapours pouring from the summit of each are adding to the deposits day by day. The island is away from all the lines of regular communication, and so far north that it is completely ice-bound from November to May. When the matter was first brought to attention an engineer was delegated to visit the place and make a preliminary survey to determine whether it was possible to successfully mine the product. The only available reports previous to that time were through traders and fishermen who had visited the island at different times. Accompanied by three Japanese engineers and a guide, the 2000-mile trip from Yokohama to Moyoro Bay and return was made in seven weeks, the members of the party suffering many privations during that time. It was discovered that the immense sulphur cones were located about two miles from the sea-coast, within easy reach of an excellent harbour, a natural incline leading gradually from the sheltered water of Moyoro Bay to a

ANOTHER VIEW OF THE SULPHUR HILLS



AT THE TOP, 2800 FEET ABOVE SEA LEVEL

point over half way up the side of the three hills. The island was found to be practically barren.

The existence of these sulphur deposits had been known to the Japanese authorities for many years, but the large amount of capital necessary to bring the product to market, and the lack of knowledge on the engineering side of the question, had delayed operations to this late date. The conditions were found to be simply these:—There were in the neighbourhood of 1,500,000 tons of sulphur lying there in an almost pure state. It would be possible, by constructing a wire-rope transmission plant, to convey the sulphur to the water's edge, and there lighter it out on board steamers of almost any draught. This work would necessarily have to be done during the months from June to October, for the winter starts in early and soon has that northern end of the island ice-bound, and so it stays until late in the spring. Snow to the depth of 25 feet covers theground during thewinter months.

On the strength of the survey and the favourable report made on the return of the original party, a Japanese company was incorporated, and Mr. Everett W. Frazar, of New York, was appointed chief engineer of the undertaking. In May, 1899, he arrived on the scene with about 400 Japanese labourers, a shipload of lumber and tools, four miles of wire rope, and a good stock of general supplies. The following five months were occupied in constructing a rope transmission plant from the base of the sulphur cones to the sea level, in putting up buildings, and in getting the barren spot ready for the busy operations that were bound to follow during the open months thereafter. In addition to all this work, the men found time to carry down about 500 tons of sulphur before the season closed and cold weather drove them away.

In May, 1900, Mr. Frazar returned and put the plant in full operation. The yellow crystals are dug out of the hillsides and carried in chutes to the upper terminus of the rope system where they are loaded into iron buckets, suspended every 300 feet along the line, and moved by gravity down to the lower end. There the sulphur is dumped automatically. The weight of the descending buckets carries back the empty ones, and the speed of the cable is regulated by friction brakes and an automatic governor.

Mr. Frazar's report of the operations from May 15 to October 10, 1900, are that 10,000 tons of the sulphur were mined and transported to the sea level, 6000 of which have been shipped to Hakodate, Japan, where a refinery has been established. The remaining 4000 tons will be refined on the ground at Moyoro Bay. Toward the latter part of the season when everything was running in full swing the rope transmission plant was able to bring down about 3000 tons per month. The season of 1901 will probably see this new industry well

HALF WAY UP THE MOUNTAIN. ONE OF THE CABLEWAY SUPPORTS

THE BUILDINGS WHERE THE OUTPUT OF THE SULPHUR MINES IS HANDLED

established, and its great commercial prominence is only a question of time.

The writer's first view of the deposits, after a long and tedious trip, showed clouds of steam pouring from several places near the summits of the hills, and far down along the sides glistened immense patches of dull yellow, which were occasionally lost to sight as a fickle breeze wafted the vapours in such a way that the brighter yellow sulphur of the summit could be seen. As already mentioned, a natural incline led from the water's edge to a point over half way up the hillsides, and much resembled a chute that the hand of man might have fashioned.

On climbing to the top, the hills were found to consist of almost pure sulphur, inasmuch as diggings at every conceivable place brought up the yellow crystals. The sulphurous vapours which poured from subterranean depths were suffocating, and, instead of issuing from only a few places as it seemed when viewed from a distance, the whole cap of each hill was really honeycombed, and each outlet was continually adding to the stock of the whole, day by day, as the vapours were condensed. A rough survey was made with a view to figuring on the proposed wire rope transmission plant, and three or four days were spent in collecting these data and procuring samples. From a business point of view everything was eminently satisfactory.

Current Topics

HAIR felt has repeatedly received mention as a means of deadening vibrations and noise from machinery, placed, for this purpose, between engine bed-plates and foundation capstones, and underneath rails subject to heavy train traffic. Now, however, cork is said to have been used in Germany with the same end in view, the available particulars being to the effect that a sheet, made up of flat pieces of the cork, in mosaic fashion, corresponding in size to the bed-plate of the noisy machine, and held together by an iron frame, is laid under the machine. What measure of success has been obtained with this new expedient is not told, though, as a means of temporary relief, it probably answered the intended purpose. The true solution of most, if not all, machinery vibration problems is, however, to be found in proper foundations, ample in area and weight, and it generally pays to provide these if at all practicable. To what exercise of ingenuity the engineer is sometimes put in accomplishing this, was illustrated a dozen or more years ago in one large factory where, on an upper floor, a row of small engines had to be installed for the independent driving of a corresponding number of different machines. Though the building was of substantial construction, with steel floor beams, it was a foregone conclusion that that row of engines would cause trouble if set with nothing but the floor as foundation, and as it was undesirable to raise them much above the floor level, each engine was provided with a separate foundation, built up of brick and mortar in the usual way, but suspended by steel straps between the floor beams and thus projecting down into the head room of the floor below. Seen from there, each foundation, with its engine, appeared as if resting on airy nothing. But those suspended foundations accomplished all that was expected of them as vibration absorbers, and are, so far as is known, still doing good service.

IN a discussion, some time ago, before one of the engineering societies, of different methods of setting steam boilers of the horizontal, cylindrical kind, the point was well made that a good deal of unnecessary refinement often enters into the setting of boilers of any type. One instance brought to notice was that of a horizontal boiler in which the rear end, according to specification,

had to be supported on hardened and ground balls, and the V guides or seats for them had to be made of steel or iron, planed and finished all over and case-hardened. While the man who drew up the specifications considered it nesessary to make such refined provision for the lengthwise expansion of the boiler,—the distance between the centres of the front and the rear brackets being only 13 feet,—he lost sight entirely of expansion sidewise. No provision whatever was made for this. From centre to centre of the ball supports crosswise of the boiler the distance was 8 feet, so that there was almost two-thirds the expansion sidewise that there was longitudinally, and it seemed odd, indeed, that any one who would go to so much trouble over the lengthwise expansion would forget all about possible trouble in the other direction.

THE cheapness with which steel is made is multiplying its uses to such an extent that estimates made of the possible wants of the world in the future can only be guesses. So says Andrew Carnegie, in a recent issue of the New York *Evening Post*, in reviewing the developments of steel manufacture in the United States. Indeed, so rapidly is the use of steel extending that it is difficult to see how the world's demands can be filled. At present the mines of ironstone and of coking coal in Great Britain are worked to their fullest capacity, and yet the output is not greatly increased; it is the same with those of Germany, except that in the latter country there remain some inferior fields capable of development if prices rise, as is probable. Russia, so far, has not been much of a factor in steel-making; if she is able to supply her own wants by the middle of the century she will be doing well. Except by the United States, Great Britain, and Germany, little steel is made, nor is any other nation likely to make much. The hopes in regard to China and Japan making steel, Mr. Carnegie believes, are to prove delusive. Great Britain and Germany cannot manufacture much beyond what they do now, so that the increased wants of the world can be met only by the United States. The known supply of suitable ironstone there is sufficient to meet all possible demands of the world for at least half of the century; in the case of coke, for the entire century. It is not to be supposed that other deposits will not be discovered before known supplies are exhausted.

A FEW years hence the export of steel and manufactures of steel from the United States to many parts of the world, which in 1899 were valued at $119,000,000, promises to be so great as to constitute another chapter in the record-breaking history of steel. The influence of American steel-making capacity upon development at home must be marvellous, for the nation which makes the cheapest steel has the other nations at its feet, as far as manufacturing is concerned in most of its branches. The cheapest steel means the cheapest ships, the cheapest machinery, the cheapest thousand and one articles of which steel is the base. The progress and commanding position of the United States as a steel-producer are told in a few words. In 1873, only twenty-seven years ago, the United States produced 198,796 tons of steel; Great Britain, her chief competitor, 653,500 tons,—more than three times as much. Twenty-six years later, 1899, the republic made more than double as much as the monarchy, the figures being 10,639,957 and 5,000,000 tons, respectively, an eight-fold increase for Britain and fifty-three-fold for the republic, and almost 40 per cent. of all the steel made in the world, which was 27,000,000 tons. Industrial history has nothing to show comparable to this.

IN spite of their great density and durability, the Australian hardwoods are not proof against the attacks of the *Teredo navalis*, or cobra, and in New

South Wales and other Australian colonies it has been customary to protect piles, before use in coastal waters, with a sheathing of copper or Muntz metal. Such a sheathing, however, according to a paper recently presented to the Institution of Civil Engineers by Mr. E. M. De Burgh, possesses certain disadvantages. It is liable to injury during the process of driving the piles, and such injury cannot be detected if below the surface; it may be destroyed or injured by objects striking and tearing it, while in water carrying sand in suspension it is quickly reduced in thickness, and is ultimately cut through; and it is costly to replace. As an alternative to metal sheathing, pipes have been used, sunk as a covering round the pile, and subsequently packed with concrete; but ordinary earthenware pipes, while presenting a good, hard surface, capable of resisting the *Teredo* and the action of salt water, are not satisfactory, as frequent faucet and spigot-joints are unsightly and impede the sinking of the pipes, while the irregularity of the pipes makes good jointing difficult, and the material does not lend itself to an improved flush joint. Further, the joints have very little strength longitudinally, which makes it difficult to handle a series of pipes. Even if successfully placed, the earthenware is readily fractured by any object striking the pile, or by expansion of the concrete inside.

It appeared to Mr. De Burgh that pipes constructed on the Monier principle, in which steel netting and wires are introduced into the body of the cement forming the pipe, thereby increasing the tensile strength, would be in every way suitable for pile covering, in places where the formation underlying the water admits of their being sunk around the pile to such a depth as to bar the entrance of the *Teredo* below them. These pipes are exceedingly strong to resist fracture, either from internal pressure or by a blow, and even if cracked, they do not fall to pieces; they can also be jointed in such a manner as to have considerable strength longitudinally, which makes them easy to handle, while the joints can be made flush. A most important advantage is that a series of these pipes will withstand the pressure necessary to force them down into the formation, without cracking, as earthenware pipes do. It might be suggested that salt water would percolate through the Monier pipes, and would destroy the steel wire foundation to which they owe their strength; but it has been found by experiment that a column of pipes, 14 feet in height, has remained for five months filled with water without showing any sign of moisture on the outside. Mr. De Burgh also considers that, even if the water did reach the wires, there could not be sufficient circulation in the Monier to enable fresh particles of water to come into contact with the wires, to continue the work of oxidation. However, additional precautions may be taken to prevent any risk of this occurring, the pipes being freely coated with tar, inside and outside, before using, thus effectually choking the pores.

A SINGULAR incident which occurred a short time ago at a silver mine in the Western part of the United States illustrated applied thermodynamics in an interesting, but fatal, manner, causing the death of one and the severe injury of another of the attending engineers. Professor Thurston told of the circumstances in an account in a recent issue of *Science*, from which it appears that the cylinder of an air-compressor exploded while in operation in regular work, and with a violence that gave evidence of more than the action of the normal air pressure in its production. The back cylinder-head and the cylinder itself were shattered, the violence of the explosion having been terrific. The two men were thrown across the room and badly mangled, and one was instantly killed. Fragments of metal and of flesh were found outside the building and a long distance away. The air pressure, at delivery from the com-

pressor, was but eighty pounds per square inch. The cause of the explosion is presumed to have been the compression of the vapours of petroleum given off by oil used for lubrication in too large quantity and of too light a quality. Mingled with air in the right proportion for combustion, the mixture of air and vapour was heated by the thermodynamic action of compression up to the temperature of ignition, and the explosion followed. This action is precisely that relied upon in one of the more recently developed types of oil motor for the ignition of its charge, independently of gas-torch or electric spark. The phenomenon has long been known to the engineering profession, although instances of this kind of accident are rare. The use of effective methods of cooling the compressor cylinder and the employment of lubricating oils of high flashing point constitute the preventives.

According to the British consul at Stuttgart, the acetylene gas industry in Germany has experienced a remarkable development. There are at least 200,000 jets of acetylene gas in use in the country, and it is impossible to predict the result of the competition between it and its rival illuminants. Probably petroleum will suffer most; coal gas will be superseded to a great extent, especially in lighting small towns, but electricity will not be appreciably affected, and he concludes:—"No other branch of industry can point to such a large and steady increase in the number of patents, showing that it has encouraged great fertility of invention. Besides producing it at home, German capital has gone abroad to produce carbide, especially to Norway and Switzerland. One of the greatest successes of the industry has been its application to the lighting of railway carriages on German Government lines. During the current year the consumption of carbide in Germany is estimated at 17,000 tons, equal in illuminating power to about 7,000,000 gallons of petroleum. Thirty-two small towns, with populations up to 5,000, are lighted by acetylene, and many more contemplate its adoption."

The economic handling of machine shop scrap formed the subject of a paper recently presented before the St. Louis Railroad Club by J. A. Carney, of the Chicago, Burlington & Quincy Railroad. From Mr. Carney's point of view, scrap may be divided into (1) borings and turnings; (2) punchings and shearings, and odds and ends weighing not more than five or six pounds; and (3) large pieces. Borings and turnings should be collected in wooden trays set under the machine, thus catching nearly all the scrap; the small quantity which falls outside the trays can be collected by the sweeper, who wheels the scrap to a bin where it can be conveniently loaded into cars. At one shop this bin is arranged something on the coal chute order. The bins are filled from a platform on one side, and are so arranged that they can be emptied into a car on the other side by means of a suitable chute or apron. By this method no shoveling whatever is done. The only sorting that this kind of scrap can be given in most shops is to keep cast iron separate from steel and wrought iron. Punchings, shearings, and odds and ends, should be put into boxes of about 200 pounds capacity at the machine where they are made. These boxes, when full, are carried to the scrap shed, where they are piled up ready for shipment to the scrap dealer, or to a central point, where it is finally sorted. If the scrap is sold, the boxes are dumped into cars. If, however, it is going to some central point for sorting, the boxes filled with scrap are carried into the cars and piled up securely. At the central point the scrap is unloaded in the boxes, sorted, and thrown into the scrap bins, the boxes being returned to the point from which they started. The advantages of handling scrap in boxes are reduced cost of labour for handling, and sorting by natural selection.

The old method of piling scrap up on the ground, then, when the pile got in the way, to move it to some other place, handling it with a shovel, or picking each piece up by hand, was expensive. The box method, according to Mr. Carney, can be practised at less than one-third of the cost of the above, and the 200-pound units, too, are easy and convenient to handle. Where work on machines is fairly uniform the scrap made must necessarily be of about the same quality. This scrap, when collected and stored in boxes, requires little, if any, sorting. In this way machine shop scrap, blacksmith shop scrap, and boiler shop scrap, especially that covered with scale, are kept separate, and can be sorted in 200-pound units much quicker and easier than if each piece, weighing a few ounces, is handled separately. The boxes used by Mr. Carney are made of 1-inch unfinished pine, and are 24 × 14 × 5 inches deep, inside dimensions. The sides are extended to make handles for carrying, and the ends are bound with hoop iron. Pieces of scrap too large to go into boxes are economical units in themselves, and are handled a piece at a time.

PROFESSOR ELIHU THOMSON

A BIOGRAPHICAL SKETCH

IN these days, when electricity is becoming almost a necessity, while but a few years ago its possibilities had not even been considered, the names of those who, from the early days of its commercial application up to the present time, have been foremost in the profession, are becoming known to a larger and larger circle. Among those none stands higher than that of Elihu Thomson, and there may be said to be none who have applied the principles of advanced theory to practical inventions to a greater extent.

Born in England of Scotch and English parents, he was brought to this country when a boy, and received his education in the Philadelphia schools. Even at an early age he showed evidences of the scientific ability which has since made him famous, and much of his time was spent in the chemical laboratory or practising on small electrical machines which he built himself. After graduation at the Central High School, he accepted a position there as assistant professor of physics and chemistry, remaining on the faculty, later as professor of the same departments, for a number of years.

From the middle of the seventies Professor Thomson had been deeply interested in the practical application of electric lighting, then in its infancy, and in the latter part of that decade he patented a number of inventions which afterwards came into general commercial use. With him was associated at this time Professor Edwin J. Houston, and shortly after these patents were taken out a number of capitalists in New England organised a company for the manufacture of electrical machinery on, for that time, a large scale. This corporation was at first known as the American Electric Company, but about 1880 its name was changed to the Thomson-Houston Company, Professor Thomson at that time becoming its electrician. From that date up to the present time he has been associated, either directly or indirectly, with the company and its successors.

The energies of the early electric companies were largely spent in the development and sale of generators and appliances for street lighting, and to the solution of this problem Professor Thomson gave his remarkable inventive and practical genius. One of the first com-

mercial series-arc lighting generators may be said to have been practically the work of his mind, and in the early eighties hundreds of generators and thousands of arc lamps were sold in every part of the world by the company bearing his name.

Professor Thomson at an early date recognised the part which alternating currents were to play in commercial electric development, and some of his inventions, which were made long before alternating machinery took its present place in electrical work, form the basis of the design of most alternating motors at the present time. During all this period he was occupied with hundreds of experiments of various kinds, many of which bore fruit, either at the time, or in the future, in the shape of valuable patents and engineering practices which have since become standard in America and, in many cases, abroad.

In 1889 Professor Thomson was elected president of the American Institute of Electrical Engineers, and in the same year was decorated with the order of Officer of the Legion of Honour at Paris. At the French Exposition of the same year he was awarded the Grand Prix for apparatus which he exhibited in connection with his inventions. Very few scientific men were able to show such an accumulation of honours received in so short a period of time.

The question of measuring electric energy in a manner applicable to the use of the every-day consumer for a long time baffled the genius of many electricians, and the recording wattmeter which Professor Thomson invented and developed up to its present high state of practical efficiency, is what has probably brought his name before the greatest number of people. This meter divided with one other the first prize awarded by the Paris Commission of 1890, which was appointed for the examination of electric meters. During recent years Professor Thomson devoted much of his time to the development of his several inventions in connection with electric welding. These have practically revolutionised several lines of manufacture, such as that of cold-drawn steel tubing.

Professor Thomson's home is in Lynn, Mass., and here is located his laboratory where his researches and experiments are carried on. It is a most interesting place, as it contains a great number of devices and machines, some completed, some scarcely started, others evidently abandoned for a better method or for some reason known only to the inventor. The Thomson-Houston Company retained Professor Thomson's services from the time of its start up to 1892, when it was consolidated with the Edison General Electric Company, forming the General Electric Company, and since that time he has remained with the latter company as its consulting electrical engineer. Latterly he has become interested in automobiles, and has developed a steam automobile which he uses himself and with which he is experimenting at the present time.

His patents impress one who studies them with the extreme versatility of his genius, as each not only contains the invention itself, but also a great number of devices and appliances by which it may be applied. Personally, Professor Thomson is characterised by that simplicity of manner which is so often found in men of high scientific attainments. He would be equally at home before an audience of children or a congress of electricians, and some of his popular lectures are distinguished by a lucidity and accuracy which we are accustomed to associate with the names of Tyndall and Faraday.

Schneider

THE HEAD OF THE FAMOUS CREUSOT WORKS IN FRANCE

SEE PAGE 415

CASSIER'S MAGAZINE

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AMERICAN TRANSCONTINENTAL RAILWAYS

By James Douglas, LL.D., Past President Am. Inst. M. E.

PART I.—THE UNION PACIFIC, CENTRAL PACIFIC, DENVER AND RIO GRANDE, AND SOUTHERN PACIFIC RAILWAYS

THE picturesqueness of railway building has nowhere been more admirably presented than along the great railway lines crossing the North American Continent. Ever since their completion they have stood as unrivaled wonders of railway engineering achievement and to-day they are still the best existing examples in the world of daring constructive enterprise and skillful execution.

Besides all this, however, there are to be borne in mind the potent influences that they have exerted on the world's history. Within a period of considerably less than half a century they have opened up to civilisation vast tracts of previously isolated territory, and have made available in the world's markets mineral and agricultural riches unparalleled in magnitude and only just beginning to be exploited. The interest, therefore, is obvious of the sketch given, in part, in the following pages, of the history, geography, and topography of these remarkable railways. It is based upon a paper read by Dr. Douglas several years ago before the American Geographical Society. Subsequently this was recast, with numerous modifications and additions, required to bring it up to date, for the information of members and guests of the American Institute of Mining Engineers on the occasion of the Institute's California meeting, somewhat over a year ago, and through Dr. Douglas' kind co-operation its republication here, nearly in full, is made possible in still further revised form. Illustrations, too, have been added of some of the difficult and wonderfully picturesque portions on the different lines, which in themselves are eloquent of human daring and perseverance.—THE EDITOR.

The Anglo-Saxon race is enterprising, but it cannot lay just claim to being adventurous. Its migratory movements have been made in no spirit of levity, but from strong religious motives, at the bidding of liberty, or under the stress of over-population. Such movements, having their origin in deep racial impulses, have been slow in their inauguration, but irresistible in their progress, and permanent in their results. When,

THE ROYAL GORGE. THE CROWNING WONDER OF THE DENVER AND RIO GRANDE RAILWAY

therefore, the race occupies territory it rarely abandons it. If it moves less rapidly than more excitable races, its tenacity in the end proves to be in proportion to its inertia.

The progress of the race on the American Continent is a commentary on these characteristics. Columbus set foot on one of the Antilles in 1492. Within half a century Spain and Portugal sent out over half a hundred discovery expeditions, and explored, with one debatable gap, the whole coast-line of North and South America from Greenland through the Straits of Magellan to the Cedros islands, off the coast of Lower California. Within that period Spain had occupied the principal West Indian islands, conquered the empire of the Aztecs and the Incas, crossed the North American Continent from Florida through Texas and Chihuahua to the Pacific, and ascended the Mississippi to the buffalo country. From the Pacific coast the Spaniards had penetrated through Arizona into New Mexico and Colorado. On the west coast of South America all the country under the sway of the Incas, including a large part of Ecuador, Peru, and Chile, was actually brought under Spanish rule, and Spain and Portugal were already rivals in discovery and occupation on the east coast of the continent. Meanwhile, Portugal had doubled the Cape of Good Hope and opened up trade with the East Indies. Such a chapter of geographical discovery throws all modern records into the shade.

The paroxysm of adventurous discovery in the fifteenth and sixteenth centuries hardly touched Great Britain. Two expeditions under the Cabots, and another in 1527 to discover the Northwest passage, all comparatively barren of results, were her only recorded contributions; and France played a hardly more conspicuous part. Jacques Cartier's story of his voyages did not stimulate the peasantry of France to expose themselves to snow, and frost, and scurvy, while the unwelcome revelation that his gold was mica and his diamonds quartz crystals removed any temptations which the French nobles may have felt to emulate the methods so successfully pursued by some of their Spanish brethren of recruiting their fortunes by discovery and conquest in the New World.

But in the seventeenth century we find the *rôle* of discoverers being played by the French. The British have founded a string of colonies along the inhospitable seaboard of New England and the hardly more attractive coast of Maryland, Virginia, and the Carolinas; but their efforts are all directed towards making comfortable homesteads in the wilderness, framing representative systems of municipal government, and securing political rights from the mother country.

A small Dutch colony has planted itself on the Hudson, but home was ever dearer to the Dutchman than to his rival, the Yankee. Spanish enterprise has been completely stifled by the extortion and grasping colonial policy of the crown. But the French have occupied Jacques Cartier's discoveries, and French traders, hand-in-hand with French missionaries, are penetrating the very recesses of the northern continent. Already long before the close of the seventeenth century, and when the British are commencing to open up by sea a trade in furs with Hudson Bay, the French have established missions and trading-posts as far west as the head of Lake Superior; and their *coureurs de bois*, adopting Indian ways and marrying Indian wives, are wandering through the Rocky Mountains and bringing back stories of the sources of the Missouri. The different spirit actuating the different people is well expressed in their varying habit of adaptability. A Virginian churchman or a New England puritan populating the West with half-breeds would be an anomaly that we cannot, by the utmost stretch of imagination, even conceive of.

A century later, at the time of the collapse of the French power in America, we find the British colonies as lethargic as before. The Hudson and Mohawk valleys had brought the British and Dutch of New York into contact with the French, and into competition with the French fur trade, but the

RIO LAS ANIMAS CAÑON, COLORADO

traffic was apparently uncongenial, and not pursued with energy. British enterprise here and elsewhere seemed to be sea-bound. It was unable to leap the Alleghenies.

The delusion with regard to the Southwest passage had been dissipated, the Pacific coast to the extreme north explored, and a wide extent of undeveloped continent was thus known to be between the two oceans; but what it contained was gathered only vaguely from the stories of the *coureurs de bois*, and such reports of Hudson Bay agents as escaped from their well-closed archives. Not a single Englishman had described, if he had crossed, the continent from sea to sea.

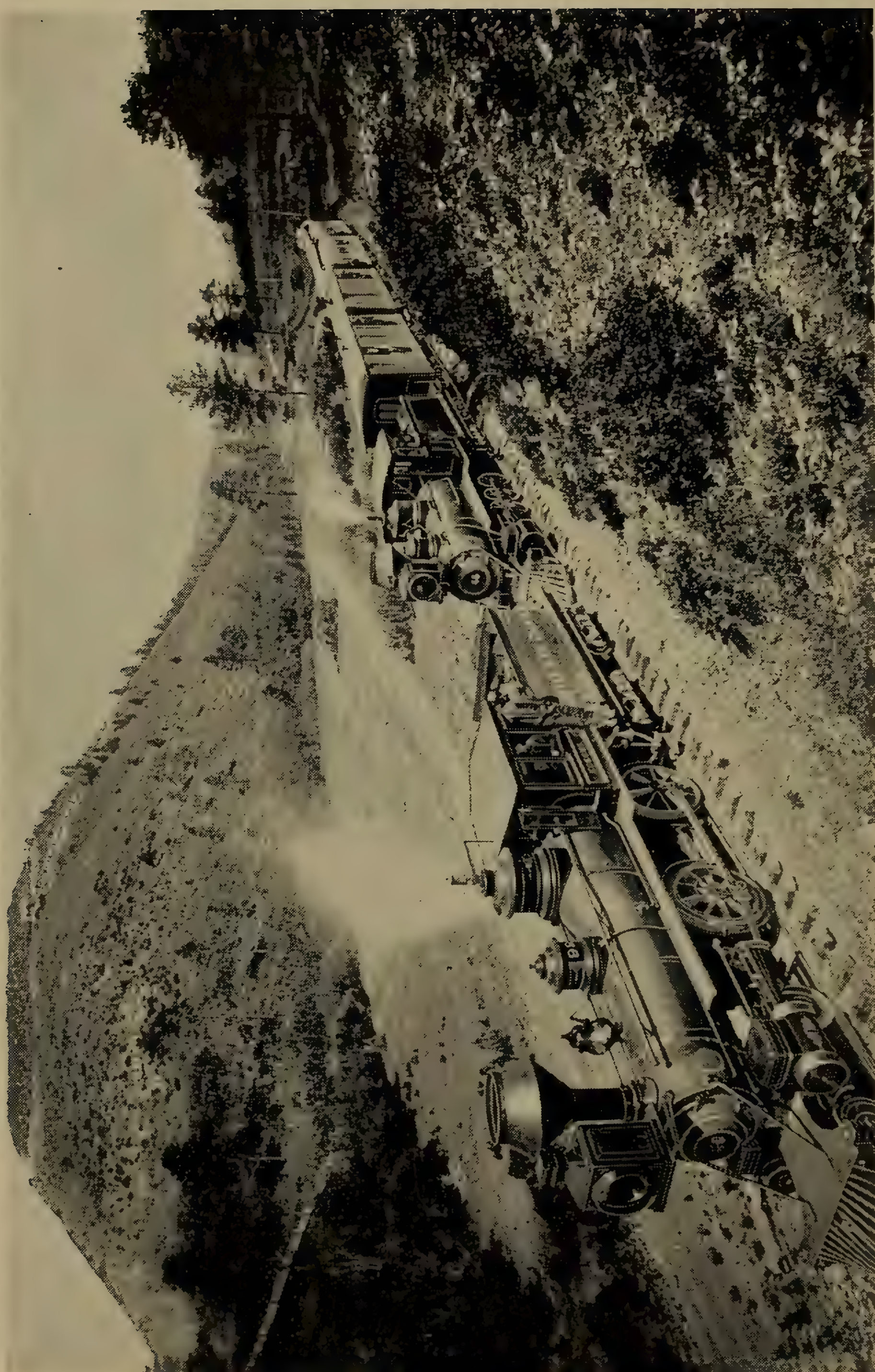
It seems absolutely incredible that a community of Great Britain's hardiest and most intelligent sons should have been content to remain for two centuries hemmed in between the sea and the Alleghenies, uninspired by the slightest curiosity to know what filled the great gap of three thousand miles between their home and the western sea, or to explore, in its northern extensions, the mountain range from which the Spaniards were gathering gold, and freighting their galleons with silver.

Carver, in 1766–67–68, explored the headwaters of the Mississippi, and described the country north and northwest of the head of Lake Superior, already long and well-known to the French. He tells stories of the tribes reported to live to the west of the Shining mountains, who had gold so plentiful that they made their most common utensils of it. These rumours stimulated him to try to cross the continent. More than one attempt failed before the American War of Independence, breaking out, frustrated his and his companion Whitworth's final plans.

Mackenzie, in 1789–93, following the wonderful waterway which, north of the British line, links the waters of Lake Superior with the Pacific by the intervention of but few unimportant portages, traversed the continent from sea to sea, and penetrated the Rockies, by the Peace River, almost to the Pacific.

The American Government, to relieve itself from the opprobrium of ignorance, despatched the Lewis and Clark expeditions in 1805. These officers of the United States Army ascended the Mississippi almost to its source, crossed the divide near the line of the Northern Pacific Railroad, descended the Clark fork of the Columbia, and reached the Pacific by the main stream, returning the following year in divided parties so as to explore more territory. Yet so small a portion of the vast region did they describe, and so vague was the information to be derived from other sources, that when Astor equipped his expedition by sea and land in 1812 to secure the fur trade of the Columbia, Mr. Hunt, who led the overland party, was in a *terra incognita* from the time when he left the Missouri, which he unfortunately did at a point apparently not far from Yankton, till he reached the mouth of the Columbia. Even such salient geographical features as the course and character of the great rivers were unknown to any member of the party,—hence the cardinal mistake of supposing the Snake River to be the main stream of the Columbia, and of abandoning their land transport service on a navigable stretch of that river, far above permanently navigable waters.

But while Lewis and Clark were exploring the headwaters of the Missouri, another government expedition, under Lieutenant Pike, first described the whole Mississippi River, previously known only at intervals, from its rise to its junction with the Missouri. He is the same lieutenant,—afterwards Colonel Pike,—whose name is so intimately associated with Colorado; for besides giving it to one of Colorado's magnificent mountains, he first, in 1806, ascended the Arkansas, and, cutting across the San Luis park, struck the upper waters of the Rio Grande. To him also the world owes its first knowledge of the country drained by the Platte. It was, of course, not till after the purchase of Louisiana, at the commencement of this century, that the government took steps to acquire some knowledge of the margins of its vast domain. But certain sections have re-



VETA PASS, COLORADO, ON THE DENVER AND RIO GRANDE RAILWAY, 9393 FEET ABOVE SEA LEVEL

mained so secluded that Custer's military expedition to the Black Hills of Dakota in 1874, only twenty-seven years ago, gave us the first accurate information about that important region.

The old Spanish settlements and towns on the Rio Grande and in Southeastern Colorado were linked to California by pueblos, such as Pueblo Viejo, Tubac, Tucson, and thus a through route from eastern United States settlements to the Pacific by the Santa Fé trail had been always open through Spanish territory. As we have seen, the early Canadian and United States explorers, in looking for roads across the continent, naturally followed the great waterways of the Missouri and Saskatchewan to such points on the Pacific as the mouth of the Columbia, whither trade relations drew them. Thus the great central zone, where the Rockies attain their grandest development, and are not penetrated or even approached by any navigable rivers, continued to be the dark spot of the continent, utterly abandoned to the red men, and trodden by only such daring trappers as Bridger.

The exploration, therefore, of the continent was incredibly slow. But as in other directions, if we are slow to move, when we do move, we move to some purpose. The Spaniards explored with the sword in one hand and the cross in the other, but left only trails behind them. We, with pick and shovel, are obliterating their trails by railroad beds.

As the northern trail was that taken by the earliest emigrants who led the way to Oregon, its advantages as a railroad route were so apparent that as early as 1835 a railroad from the upper Mississippi to the mouth of the Columbia was actually proposed. But the project was not acted on seriously till 1845, when Asa Whitney nearly succeeded in securing from Congress a land grant in aid of the first Northern Pacific, before which more recent grants dwindle into insignificance.

In 1848 the Mormon exodus from Illinois and the occupation of the promised land of Deseret was completed, and the country was surprised at learning that in the heart of the great American desert a land existed which flowed with milk and honey, and only waited to be cultivated. The government, therefore, in 1849, undertook a survey of the great basin, under Captain Stansbury and Lieutenant Gunnison.

In 1848 gold had been discovered in California, in the year of its transfer from Mexico to the United States, and the adventurous spirits of both hemispheres flocked thither. To most, the straightest road was the best. Neither the high walls of the Rockies nor the snowy summits of the Sierra Nevada could deter them. California, not Oregon, henceforth became the objective point of the emigrant, and railroad projects now pointed to California, not to Oregon.

The government in 1852–54 sent out surveying parties in search of railroad routes across the mountains. Their work, as embodied in the famous document issued by the United States War Office (Jefferson Davis being Secretary) from 1855 to 1860, "Reports of Explorations and Surveys to Ascertain the Most Practicable and Economical Route for a Railroad from the Mississippi River to the Pacific Ocean," covered preliminary surveys of five possible railroad routes, as follows:—

(1) A route was surveyed under Governor Stevens along the 47th parallel, the eastern portion of which closely corresponds with the location of the eastern sections of the present Great Northern Railroad, and the western portion with the line selected for the western sections of the Northern Pacific Railroad.

(2) Captain Fremont, Stansbury, and Lieutenant Beckwith surveyed the country between the 41st and 42d parallels, and proposed a route not widely different from that selected for the Union and Central Pacific railroads.

(3) Captain Gunnison lost his life at the hands of Indians, or of Indians and Mormons, while trying to trace a practicable road along the 38th and 39th parallels, through the sea of mountains which the Denver and Rio Grande and

the Rio Grande and Western railroads now traverse between Pueblo and the Salt Lake valley.

(4) Lieutenant Whipple surveyed the country now opened by the Santa Fé Pacific Railway, near the 35th parallel.

(5) Captain John Pope, Lieutenant Parke and Major Emory described the route along the 32d parallel, now occupied by the Southern Pacific Railroad, which the Secretary of War recommended as the most desirable, on the score of length, climate, and gradients. The extension of this route, from the mouth of the Gila to San Francisco, was explored by Lieutenant Williamson.

The State of Missouri was the first to charter a transcontinental route, under the name of the Missouri and Pacific Railroad Company. It was to start from St. Louis, and, after running southwest, to follow the 36th parallel through the present Indian Territory to Santa Fé, and thence across to the Pacific. The Civil War frustrated this scheme, but hastened the accomplishment of another. To build a road through a region within the radius of actual war was hazardous. Yet California, isolated from the rest of the States, it was seen, must be brought within rapid reach of the central power. Hence the organisation of the Union and Central Pacific companies, and the liberal assistance tendered them by the government, to build a road from the Mississippi to the Pacific, far north of the strife then raging. The charters were signed in July, 1862; the first sod was turned on the Central Pacific February 23, 1863; but work was not commenced on the Union Pacific until November 12, 1865, after the immediate cause for urgency had passed. Fourteen years, or to July, 1876, were the limit of time allowed by the charters for the completion of the joint enterprise; but the eastern and western sections met, and the last spike was driven at the station of Promontory, on May 10, 1869.

This station is 1084 miles from Omaha, but only 850 from San Francisco. Yet, taking into account the much greater engineering difficulties which beset the Central road in crossing the Sierra Nevada than those which obstructed the Union road in the Rocky Mountains, as much credit is due to the one as to the other.

In 1864, before work on the Union Pacific Railroad had been commenced, the Northern Pacific Railroad Company obtained a charter. Governor Stevens' survey, in 1853, of the northern route had proved its practicability; but this company, organised by Mr. Perham, sought in vain for financial assistance till Jay Cooke & Co. came to its rescue, and effected thereby their own ruin. Construction was commenced in 1870, but, by reason of many financial vicissitudes, the road was completed only in 1883.

But individual energy had been at work in the extreme south of the western domain. Before this date the Southern Pacific had been opened from end to end. While the Texas and Pacific Company, chartered in 1872 to construct a road from Fort Worth, in Texas, to San Diego, on the Pacific, was languidly building from the east, and vigorously soliciting government aid, the large stockholders of the Central Pacific were constructing a line with their own resources along the proposed route of the Texas and Pacific from the California end. And thus before the Texas and Pacific had laid their tracks through the State of Texas, the Southern Pacific had occupied Lower California, Arizona, and New Mexico, and united with the Texas Pacific proper in Texas at the end of 1882. Contemporaneously, the Atchison and Topeka, originally a road looking for support to the agricultural resources of Kansas, had crossed the Raton spur of the Rockies, earned the right of adding Santa Fé to its title, and, by connecting with the Southern Pacific at Deming, created another Rocky Mountain Railroad. Since then this company has made an independent outlet for itself to the Pacific at San Diego, by the Atlantic and Pacific Railroad (now the Santa Fé Pacific) and the California Southern.

While these broad-gauge roads were

MAP SHOWING ROUTES AND ALTITUDES OF TRANS-CONTINENTAL RAILWAYS

seeking for valleys and easy grades by which to cross the mountains, a narrow-gauge road (controlled by officials, and constructed by engineers, with very broad-gauge ideas), the Denver and Rio Grande was successfully combating difficulties and scaling heights which only lavish expenditure of money, handled by the highest engineering skill, could overcome. This road was intended to be a link through the valley of the Rio Grande, between the Southern and Central systems; but the Atchison and Topeka forestalled it. The management then divided its energies between fighting the Union Pacific and reaching the most inaccessible regions in Colorado. The marvellous feats which its builders have really accomplished are as wonderful as those the Union Pacific was supposed by popular imagination to have performed. Though commenced as a narrow-gauge through-line via Pueblo and the Royal Gorge, with, subsequently, a branch to Leadville, it was completed by an independent company from Grand Junction to Salt Lake City as a standard-gauge road, under the title of the Rio Grande Western Railroad. At present it makes connection with the Colorado Midland, by which it secures a standard-gauge track from Denver to the Great Basin. But it, of necessity, retains the 36-inch gauge for its line over Marshall pass, and its many tortuous branches. The last road to link the waterways of the Atlantic coast with the Pacific is the Great Northern. Begun as the St. Paul, Minneapolis and Manitoba, to afford railroad facilities to the rich Red River valley, it was extended into Montana in 1887, and has reached Puget Sound at Everett, and tapped the mining regions of British Columbia. Other Western roads are pushing across the continent, the Chicago and Northwestern taking the lead, all the railroad companies recog-

nising the fact that the trade with Asia is certain to be an increasing factor in American commercial life.

The geographical and topographical features of those sections of the continent which these roads traverse, as exhibited in their profiles, are laid down in the map on the preceding page. The Rocky Mountains, including the whole system of mountains and plateaus from the plains as far as the Pacific coast, attain their greatest development in height and width along the 41st parallel, which nearly coincides with the line of the Union and Central Pacific railroads, and there exhibit, with marked prominence, all their features, the principal of which are high and steep eastern and western chains, the Rocky Mountains to the east, and the Sierra Nevada to the west, enclosing an elevated plateau corrugated by diagonal minor ranges. To the west of the western rim is a coast valley, itself protected from the sea by a coast range. This structure, with such variations as nature loves to indulge in without departing from uniformity of type, is maintained along the west coast of both North and South America, as well as in the structure of other continents. It is well illustrated in the sections made by the Rocky Mountain railroads. In fact, until railroad surveys were made, accurate topographical maps of extended regions had been, probably, nowhere produced.

THE UNION PACIFIC RAILROAD

The profile of the Union and Central Pacific roads exhibits these features better than that of any other road. The plains rise by a grade, so easy as not to be appreciable to the eye, from 968 feet at the Missouri to 6038 feet at Cheyenne, or 5070 feet in 516 miles, the country changing with the decrease in rainfall from the rich fertility of the Nebraska prairies to grazing lands, dry and seemingly valueless, but able formerly to support the buffalo, and now their tamer successors.

At Cheyenne the Laramie hills rise abruptly from the plain; but, like all hills looked at from below, the steepness is illusory, for the train scales them to Sherman, a point 8235 feet above the sea, in 33 miles, and then descends into the Laramie plains, whose average elevation is about 6500 feet. This is in reality the most northerly of the parks, though not generally ranked among them. The plains are well watered by rivulets which flow north into the North Platte, the main stream of which is separated from the plains by a ridge 7168 feet in altitude, over which the road runs before ascending the Continental divide, here only 7100 feet above sea-level, and, therefore, more than 1000 feet lower than the summit of the Laramie hills at Sherman, and but 500 feet above the average level of the rolling plains which intervene. To the north and south high mountain ranges break the surface of the plateau, but the profile shows what an easy highway nature offered the railway builders across the great basin on this parallel. It was always the Indian's and trapper's trail, and was, in 1852, suggested by Lieutenant Gunnison as a feasible railroad route before the official survey.

To the north and northwest can be seen the Seminole mountains, the Sweetwater range, and in the far distance the Wind River Mountains; to the south the Elkhead Mountains, and away to the southwest the spurs of the Uintah range. From the summit there is a down grade to the Green River, for sixty miles of the way along the Bitter creek, through an utterly desolate region, the cliffs on either side encroaching close on the valley. The sandstones which here accompany the coal that underlies Wyoming, east and west of the Divide, favour the sterility which elevation and drouth alone are enough to produce, but add to the scenic effects by weathering into picturesque bluffs. The Green River, one of the great branches of the Colorado, is the first, and only large stream which flows into the Pacific, along this parallel, till the Sierra Nevada is passed; the river and lake system of each section of the great basin,—the Utah section and the Nevada section,—being self-contained.

The Uintah range, whose axis is nearly east and west, is now the con-

spicuous feature to the south, its sides covered with forest, and at its base Beaver creek, which was Bridger's favourite trapping-ground for the American Fur Company as far back as 1820. Up the Big Muddy the railroad now ascends a spur of the Uintah, crosses it at Aspen at an elevation of 7835 feet, and descends into the valley of the Bear. This stream, like many others in the Rockies, doubles on its own course. It rises to the south of the track, flows north, outflanking the Wasatch range, and returns south to discharge, after a course of 230 miles, into the Great Salt Lake, not over sixty miles west of its source. But the railroad builders tunneled the high, jagged range at Wasatch, and carried the track through the wonderful rock scenery of Echo and Weber Cañons, down the steep western slope of the Wasatch to the Salt Lake valley at Ogden. To secure some of the traffic of the Northern Pacific States, and gain closer access to the sea, the Union Pacific built the Oregon Short Line, which runs diagonally through parts of Wyoming and Idaho from Granger, in the former State, to Huntingdon, on the Snake River, where it connects with the Oregon Railroad and Navigation Company, which affords the most direct route to Portland via the Columbia River.

Five roads radiate from Ogden,—the Union Pacific towards the east; the Central Pacific towards the west; the Denver and Rio Grande towards the southeast; the Utah Central runs due south down the valley; and the Utah Northern, built first as a narrow-gauge road, but, in consequence of the extraordinary growth of Butte, converted into a standard-gauge, runs due north through the eastern section of Idaho into Montana, where it connects at Garrison, at the western foot of the Rocky Mountains, with the Northern Pacific. But the original, and still the main connection of the Union Pacific, is with the Central Pacific.

THE CENTRAL PACIFIC RAILROAD

From Ogden westward the Central Pacific, after crossing from the Utah into the Nevada depression of the Great Basin, descends, by easy grades, to the eastern foot of the Sierra Nevada, through a region even more desolate than that traversed by the Union, between naked mountain ranges, over long stretches of rolling sage-bush plains, hardly redeemed from utter sterility by a ribbon of verdure on the banks of the Humboldt River. The railroad follows the valley of this river from Moore Station for a distance of 350 miles till it enters the Humboldt Lake, and, flowing thence, loses itself in the sink of the Carson.

The profile shows this westerly basin, occupied by the Humboldt and other lakes, to have almost the same level as that of the Great Salt Lake. Into it flow the Humboldt from the east, and the Carson and Truckee rivers from the west, all perennial streams carrying large bodies of water; but the thirsty sands and the rapid evapouration from the lakes, which these rivers form, drink up all they contribute. Carson Lake, which, like the Great Salt Lake, of Utah, is the residuary recipient of the whole river and lake system of this portion of the Nevada desert, has no outlet.

The valley of the Truckee was selected by the railroad engineers as the most feasible route out of the basin. In approaching the valley of the Truckee, the railroad traverses, from Lovelocks to Wadsworth, for about sixty-three miles, a desert region white with alkali, and full of solfataric activity, bubbling with hot springs, which are saturated with soda and borax, and underlaid by beds of brimstone. Thence it follows the narrow channel of the Truckee (too barren generally to produce much, even with irrigation) to the town of Truckee, a distance of sixty-two miles, gaining an elevation in that distance of 1742 feet.

At Truckee commences the pull up to the summit, a distance of only fourteen miles, in which 1198 feet of elevation are gained. The scenery of Donner Lake, which the train skirts after leaving Truckee, the piles of mountains rising more than 3000 feet above the tunnel by which the road cuts through

CURRECANTI NEEDLE IN THE BLACK CAÑON OF THE GUNNISON, COLORADO

the crest of the Sierra, and, on the western side, glimpses of the birth and growth of the streams which dash down through the forests to feed the Sacramento, give this section of the road preeminence in beauty; but what between tunnels and fifty miles of snow-sheds, the traveller is kept in a state of constant irritation,—as angry as when, in New England, expecting to get the full view of a beautiful river, he enters a covered bridge. Down the western slope of the Sierra the train speeds from the summit, at 7017 feet, to Colfax, a descent of 4595 feet in fifty-one miles, through the pines, into the oak glades, and down to the plains. The relief of passing, at a bound, from the most desolate spot on the continent, the Humboldt desert, into one of the most fertile of the world's valleys, that of the Sacramento, is intense. The Coast range does not appear on the profile, because the railroad terminates on the Upper Bay, formed by the junction of the Sacramento and the San Joaquin rivers, and this great harbour is carved out of, and sheltered by, the Coast range, on whose hills San Francisco itself is built.

THE DENVER AND RIO GRANDE RAILROAD

The Denver and Rio Grande, as already observed, surpasses all competitors in the feats of engineering its builders have achieved. Each of its branches was, at the time of construction, the most remarkable deed of daring yet attempted, and each successive effort has surpassed its predecessors in boldness of conception and execution. The map would be covered to confusion, were we to attempt to show each of the Denver and Rio Grande lines. The first mountain branch was that over the Sangre de Cristo range by the Veta pass, thence across the San Luis park and down the valley of the Rio Grande to near Santa Fé. From this two feeders diverge to the San Juan and to other as inaccessible mining localities, heretofore deemed difficult of approach by ordinary vehicles.

The main line, as originally located, ran from Pueblo, over the Marshall pass, to Salt Lake. The gauge was 36 inches, and it was expected to be the forerunner of many another 36-inch road,—an anticipation which has not been realised. In its course it cuts the Rockies at their highest and wildest, to the west of Pueblo, taking advantage of the Arkansas to reach the water-shed of the continent at Marshall pass.

The Royal Gorge, in the Grand Cañon of the Arkansas, is the portal which admits the traveller from the plains into the recesses of the mountains where the river receives its life. Above the cañon the valley widens, and is productive of grasses and of such vegetables as the great altitude permits to come to maturity. At Salida the branch to Leadville continues up the Arkansas, but the main road ascends the Saguache range to the Continental divide. This is crossed by Marshall pass at an elevation of 10,820 feet, by grades reaching 220 feet to the mile.

From this great elevation the eye wanders far and near over forest-clad mountains with rounded outline, less startling, perhaps, but more pleasing than the bare sides and jagged profiles of the Eastern and the Sangre de Cristo ranges, for colours and curves are principal elements of beauty. If they do not elicit wonder, they excite pleasure. Nature, when clad in neutral tints, is bereft of half her charms. Looking from this vantage ground, it would seem impossible that the railroad could find a path through the network of ranges, the peaks of which tower to north and south and east and west to elevations of 12,000 and 14,000 feet,—not one peak, but many. Yet though the road follows river courses, they are not always river valleys, but deep, steep gorges, over whose stony sides the engineers had to be suspended in locating the road, and the miners in dislodging the rocks to gain a footing for the road-bed.

The Tomichi River, the main confluent of the Green, is reached almost at once after the Divide is passed, and where this branch unites with its northern sister to form the Gunnison, is rising the city of Gunnison, at an altitude of 7680 feet. Below Gunnison the river

OPHIR LOOP ON THE RIO GRANDE SOUTHERN LINE. HERE THE ROAD WINDS IN ZIG-ZAGS DOWN THE MOUNTAIN SIDE

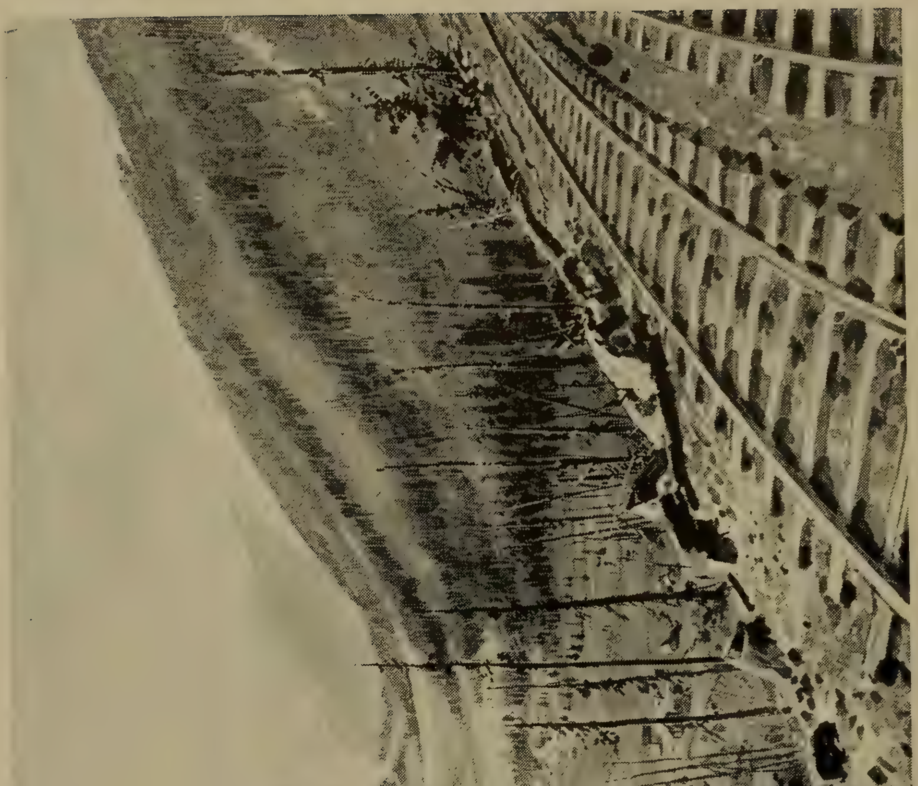
cuts through mountain and plateau, creating the Black Cañon of the Gunnison, less gloomy than the Grand Cañon of the Arkansas, and enlivened by a greater variety of rocky outline, for the gorge has been carved out of limestones and sandstones, instead of riven through the old crystalline rocks. It is broader, and is streaked with colour derived from the weathering of the rocks, as well as from vegetation. The Gunnison Cañon becomes more rugged below Gold creek, and, rather than follow it, the road crosses Squaw Mountain and joins at its western base the Uncompahgre branch of the Gunnison. This it follows to its junction with the main river at the town of Delta, and it still keeps to this highway of nature across the Grand mesa till it unites with the Grand River at Grand Junction. For 200 miles farther westward the Rio Grande Western road ascends a series of barren steppes before surmounting the Wasatch and entering the Great Salt Lake valley. From Grand Junction to the Great Basin the Rio Grande Western is of broad gauge. At Grand Junction the (originally narrow gauge) Leadville branch of the Denver and Rio Grande, which leaves the main transcontinental line at Salida, rejoins it, after having tapped Leadville, crossed the range by the Tennessee pass, and connected with the Aspen district via Glenwood Springs.

The Colorado Midland, a standard gauge road, which runs from Denver through Colorado Springs, Manitou, and Buena Vista to Leadville, follows a parallel route to the Denver and Rio Grande from that point to Grand Junction. Leadville, therefore, enjoys the services of three roads,—the Denver and Rio Grande, a branch of the Union Pacific, and the Colorado Midland.

THE SOUTHERN PACIFIC RAILROAD

The Southern Pacific is now the only United States railway whose termini are on the two oceans,—the eastern at New Orleans, the western at San Francisco. It runs through the swamps and across the bayous of Louisiana, over the low coast lands of Texas to Houston, and thence traverses from east to west its fertile cotton fields to beyond the old Spanish town of San Antonio where the land grows less fertile. At 170 miles from San Antonio the road enters the Cañon of the Rio Grande. Through this it is built on benches overhanging the river, and within a stone's throw of the Mexican shore, till it reaches the undulating limestone plateau through which the river has cleft this narrow trough. On the plateau the scenery differs from that of the plains to the north only in the vegetation which clothes it. We are on the "*Llanos estacados*," the "Staked plains," of other days. Though no river runs for hundreds of miles through this dreary waste, springs occur, and water in many places is pumped to the surface to supply the cattle and sheep which roam over this scorched wilderness. These, though necessarily few in number to the mile, are an immense multitude in the aggregate. Not a hill breaks the horizon for more than a hundred miles, but the road ascends gradually to Sanderson, where short, isolated ranges commence to rise out of the plateau, and the mountain scenery assumes the aspect which it henceforth bears along the line of road all through New Mexico and Arizona, till the Colorado is passed and the Yuma desert is entered. This company operates to-day the Central Pacific to Ogden, Utah, as well as the through line from Portland, Oregon, to San Francisco, Los Angeles, and New Orleans, with many branches, comprising nearly all of the railroad system of California.

The Rocky Mountains, as we have seen, attain their grandest development in Colorado. In Northern New Mexico they still maintain their character as an unbroken Cordillera. But further south it becomes impossible to identify the features which we have seen the continent to possess along the 41st parallel. In Western Texas, Central New Mexico, and in Northern and Central Arizona there is a complicated system of short ranges so interlocked as to leave but narrow valleys between; while in the southern portion of these territories



SULTAN MOUNTAIN ON THE RIO GRANDE SOUTHERN LINE

similar ranges, with a general northeast and southwest axis, spring from the lofty plateau, whose average elevation is about 4000 feet, in isolated mountain masses, with great stretches of intervening plain. The Texas Pacific Railroad has crossed the same plains to the north of the Southern Pacific, and entered the same mountain scenery in its straight course from Fort Worth to Sierra Blanca, where, at ninety-one miles from El Paso, on the Rio Grande, it unites with the Southern Pacific. Westward the single railroad winds among these miniature ranges without, as the profile shows, any great variation in grade, and yet by a route so tortuous that long stretches are built to reach points a few miles apart. Mountains with bare flanks, but crowned by a fringe of pines, before and behind, and on either side, close in every view, while yet the train is gradually crossing a plain of sandy or baked reddish soil, sprinkled with tufts of grass and dotted with soap-weed or yucca, bushes of grease-wood, and groves of mesquite, and, in places, groups of huge cacti and smaller members of the same grotesque family. Only two rivers, the San Pedro, at Benson, and the Santa Cruz, at Tucson,—the latter generally dry,—are crossed between the Rio Grande and the Colorado, a distance of 550 miles. The Rocky Mountains have been completely shattered, and their scattered fragments seem to strew the plains. They reunite in the Sierra Madre of Chihuahua, immediately south of the line, recover from their disorder, close up their ranks, and present an unbroken front southward to the Isthmus; but in New Mexico and Arizona they have been completely obliterated as a Cordillera.

The Rio Colorado is crossed at sixty miles above its mouth, where it flows between low, sandy banks; for the Grand Cañon has terminated hundreds of miles above, before the river has turned from its east and west to its north and south course. Before reaching the river the country traversed has become, if possible, more forlorn, and desolation reigns supreme. After the bridge is crossed the Yuma desert is entered. In traversing it the train runs for hour after hour over plains of sand, thirty miles of which are below sea level. At all seasons a mirage is seen, as tempting as any which deludes the African traveller. At places the sandy surface is flat, at others it rises into hillocks like the dunes of Holland. Fields of pure white salt and alkali alone break the colour-monotony of the yellow, sandy plains and sun-baked mountain ranges. The San Bernardino Mountains rise steeply ahead, their slopes as bare and rocky as the mountain ranges between which we have been passing now for over 1000 miles. They represent the Sierra Nevada Mountains, which, along this zone of the continent, dwindle, like the Rockies, into insignificance. Further south they continue to assert themselves, but still more feebly, in the peninsula of Lower California, before being lost in the Pacific.

As we ascend the eastern slope of the San Bernardino range, the desert merges into arable land, but the summit of the Gorgonia pass is so speedily reached that the train seems to leap, as if by magic, from dreary sterility into the orange groves of Colton and Los Angeles and the rich verdure of the San Fernando valley. Here the Coast range to the west is well defined; but the coast valley in which this oasis is enshrined rapidly contracts to the north, and the Sierra Nevada and the Coast ranges coalesce into a network of cross-ranges through which the selection of a practicable railroad route was no easy task. That selected passes from the head of the valley easterly through the Soledad pass into the Mojave desert, the northerly representative of the Yuma desert, over which we travelled, and then returns, through a maze of mountains, over the Tehachape pass northwesterly into the great longitudinal coast valley. In crossing the pass the grades are reduced by making the road describe the figure ∞ round two adjacent isolated hills forming the well-known loop.

This is the last engineering feature of note in the Pacific section; for the road does not again leave the broad, fertile plain of the San Joaquin valley, closed,

to the east, by the high, snow-capped boundary of the Sierra Nevada, enshrining the Yosemite and other almost as beautiful, if not so famous, pieces of scenery, and, to the west, by the lower wall of the Coast range. The Southern Pacific had been running its trains through to the Atlantic for five years before it connected its Southern California section with the Oregon road, which ran south from Portland through the Willamette valley. That amalgamation and connection made, the Southern Pacific Company has been in a position to tap, by its own track, the trade of the whole Pacific coast, almost from Puget Sound to the Mexican line, to drain the heart of the continent by the control of its central section, and to span the continent from the Pacific to the Atlantic. The geographical features of the Shasta division, as the road from San Francisco to Portland is designated, bear a general resemblance to those between Los Angeles and San Francisco. From Sacramento northward the road occupies the Sacramento valley, corresponding to the San Joaquin valley on the south, between the Sierra Nevada and the Coast range. At its northern head this great interior valley-area of California is enclosed by the Siskyou cross-range of hills, which the road traverses amid magnificent scenery. Thence it passes northward, through the valley of the Willamette, to the junction of the latter with the Columbia, at Portland. North of the Sacramento valley, the mountains (here called the Cascade range) assume grand proportions, culminating in the magnificent peaks of Shasta, Hood, and Rainier.

Part II. of this article, which will appear in the April number of this magazine, will deal with the Atchison, Topeka and Santa Fé Railway, the Santa Fé Pacific, the Great Northern, and the Canadian Pacific Railways, and, in addition, will contain some of the more important statistics relating to these lines, and general conclusions.

LATE PRACTICE IN UTILISING BLAST FURNACE GAS

AS A GAS ENGINE FUEL

By William H. Booth, Mem. Am. Soc. C. E.

THE utilisation of the waste gases of the blast furnace has not made the progress that might have been expected in view of the fact that the gas has such an enormous calorific value. Utilising blast furnace gas was first suggested by Mr. B. H. Thwaite, and to some extent was, as so many of the best ideas have been, partially accidental. At the time that Mr. Thwaite was making experiments with his gas producer and was frequently analysing its product, he noticed the remarkable similarity between this gas and a sample of blast furnace gas, and the idea very naturally and fitly suggested itself that a blast furnace might become a source of power by means of gas engines.

In the first place, in order to render his foundation sure, he made up a gas by means of the small producer on which he was experimenting and found that even with as much as 12 per cent. of carbon dioxide the producer gas worked well in the gas engine on the Otto cycle. This enabled further work to be done in preparing an actual demonstration plant, and a gas engine of about 20 H. P. was laid down at the Wishaw Iron Works, near Motherwell, Scotland, where it is still in operation, driving the electric generator that lights the works.

This was the first blast furnace gas-driven plant put down; but the system became known, and was promptly taken up by the Seraing Works, in Belgium, where a plant of much larger size was soon installed. A test was made upon the Wishaw plant by the writer, and with so small an engine very good results were secured,—about 1 electrical horse-power at the switchboard for each 140 feet of uncooled gas. This represents about one and one-half pounds of coal. Thus it appeared that in the first practical attempt to use the waste gas, power had been produced from as small a weight of fuel as was possible with the best steam engines. But the fuel had already done its work in smelting iron, whence it appeared that a gas producer had been found that made iron as a by-product.

This leads up to the consideration of the action of the blast furnace. In the zone of the tuyeres combustion of carbon is fully effected and a high temperature is generated, the iron being fully liquefied. As the highly heated gas ascends in the furnace it encounters a mixture of highly heated iron ore and fuel. From the fuel the gas absorbs a second atom of carbon, the action being $CO_2 + C = 2\ CO$. But the monoxide of carbon gas thus produced is very greedy for oxygen. The only oxygen available is contained in the ore, which is more or less an oxide of iron. The iron is separated from its oxygen by the superior affinity of the carbonic oxide gas, and falls down as metallic iron through the zone of maximum temperature to the hearth.

The ascending gas, again partially converted into carbon dioxide, passes upward through the upper layers of fuel and ore. It parts with some of its heat to the ore, which it is, however, powerless to reduce to metal, and part of its heat is again rendered latent by a fur-

ther dissolution of carbon, as well as by dessicating the ore. The gas that finally escapes has comparatively little dioxide in its composition. It is chiefly carbon monoxide and nitrogen, and it is not of high temperature,—probably about 500 degrees. Its heat has become latent in absorbing more carbon.

It is obvious that the blast furnace differs but little from the ordinary gas producer. Such differences as there are consist in the production of a fluid slag, due to the zone of high temperature, and in the great height; but it is now recognised that, as pointed out by the writer, the blast furnace is an ideal gas producer, and the best producers are those most closely modelled on its lines. Such being the case, it is easy to see that there is no reason why large amounts of power should not be obtained from blast furnace gases.

Blast furnace gas has one peculiarity, —it is highly charged with fine dust. It is also full of moisture. The dust makes it unsuitable for direct use, or unpurified, in the gas engine, and the moisture makes it unsuitable until cooled. No real success can be looked for without cleaning. By the use of condenser pipes the gas may be cooled, and it will also deposit some of its dust, but final dust deposit is best effected by means of a sawdust filter. The importance of cooling is great, for in no other way can the moisture be eliminated, and moisture is a great enemy of efficiency in power production.

The calorific capacity of blast furnace gas averages 100 British thermal units per cubic foot, and it contains about 33 per cent. of combustible gases, the remainder being inert and chiefly nitrogen. Thus, like producer gas, it demands an alteration in the proportions of the gas and air inlets of the engine, the first being enlarged and the second reduced. But in spite of its small calorific capacity, an engine using it will not fall in power so far below an engine using coal gas, because in the latter case the charge of gas is so much smaller, the gas being too powerful to use in large charges.

The most obvious use for blast furnace gas power is, of course, the driving of the air-blowing engines that supply the blast to the furnaces themselves. Hitherto blowing engines have been steam actuated. Steam is raised by burning the waste gases under boilers. As blast furnace gas is one of the clear-burning gases and contains no solid carbon in its flame, it has an exceedingly small heat radiating capacity, and the efficiency when burned under steam boilers is very small. Sometimes the gas will not even ignite. When used in the gas engine, however, the power obtainable is about sixfold that to be obtained from steam engines per 1000 cubic feet used. Moreover, all difficulties of ignition disappear, because in the gas engine ignition of the gas at atmospheric pressure is not attempted, but only when under several atmospheres of compression. In compression, with the air necessary for combustion, there is no difficulty whatever with the poorest gas yet tried. By using, then, waste gases to drive their own blowing engines, ironmasters have brought under their notice in a most practical manner what the gas is capable of doing, and they will be encouraged to prosecute schemes for turning to account the immense volumes of gas that now go practically to waste, for the use of the gas under boilers cannot be characterised as other than a shameful waste when methods are known by which sixfold the useful effect can be secured.

The system of furnace blowing by the furnace gas itself has been adopted not only by the pioneer of the whole movement, Mr. B. H. Thwaite, but by the already mentioned Seraing Company, in Belgium, and by the Hörde Iron Works in Westphalia, Germany. Taking the Continental firms first, because of the presence at the Paris Exhibition of the Seraing engine on the Delamare-Deboutteville system, it is to be noted, that the air cylinder in that blowing engine was placed tandem with the gas cylinder. The engine was rated at 700 H. P. with furnace gas. It had one cylinder working on the Otto cycle, and drove the air blast piston direct

by a tail rod, while its crankshaft carried a heavy fly-wheel.

In the Hörde engine there are two pistons in one cylinder. These move in opposite directions, and the explosion takes place between them. By means of a pair of side rods and a crosshead the rear piston is coupled to a pair of cranks, placed opposite to the single crank of the front piston. To the crosshead is attached the rod of an air-pump which furnishes the gas and air mixture.

The exhaust, air, and gas ports are at the forward end of the cylinder, and are uncovered by the pistons on their out-stroke. The engine is thus a development of the Clarke gas engine, and secures an explosion every revolution. Scavenging air is admitted, previous to the gas mixture, from the blowing cylinder, and promotes cleaning and cooling. This engine was the first really large engine to be worked from a blast furnace.

Other large gas engines are in course of construction on the European Continent, showing that the Thwaite system has been appreciated and appropriated by foreigners at a more rapid rate than at home. Unfortunately, some engineers on the Continent have made the mistake of trying to use the dusty gas without purification, and this has been prejudicial to success. This attempt has been abolished, and even at Seraing, where the gas is claimed to be comparatively free from dust, means have been taken to get rid of the dust. In Great Britain, however, no attempt has been made to avoid purification. It has been recognised as essential, and proper means have been taken to cope with the dust by scrubbing and filtering the gas.

A recent installation of the Thwaite system of purification is that at the blast furnaces at Boulogne. The fuel employed is coke, and the ore is a mixture of Spanish and French with limestone flux. The gas analysis is below, the figures being an average of six samples taken on different days. The hydrogen is so small in volume as to be negligible, and it has been counted in as nitrogen, the water vapour having been determined by condensation:—

BLAST FURNACE GAS ANALYSIS.

	Percentage and Volume.
Carbonic acid, CO_2	10.0
Carbonic oxide, CO	28.0
Hydrogen } Nitrogen }	62.0
	100.0
Water vapour	2.4%

Measured at 60° F., the thermal value for one cubic foot is 118 B. T. U.

After leaving the furnace, the gas is purified by a system of washers and scrubbers, and is delivered free from dust or excessive moisture, at atmospheric temperature, and also at constant pressure from a pressure regulator holder. The success of the gas should thus be assured. Where the dust is neglected in the hope that it will not prejudicially affect the results or ruin the engine, disappointment is sure to follow. It is unreasonable to suppose that dusty gas can be admitted into a working cylinder without producing great friction and wear and tear.

Much of the dust is very fine. It consists of coke and ore. Coke dust is particularly cutting in its action, and this is the part more likely to enter the engine if not purified out. The heavier particles come from the ore, and it has been estimated that blast furnace gas contains, on an average, nearly half of one per cent. of dust by weight, while even in wasted gas two and three grammes of dust have been found in each cubic meter of gas. This dust can be best removed by means of the sawdust filter, the interior of which is rapidly detachable for removal of the filtering material.

The importance of reducing the moisture lies in the fact that not only does it shut out of the cylinder the power-producing gases, but by its own heat-absorbing power it reduces the effect of explosion. The gas is drawn from the furnaces through the washer, and is propelled through the scrubbers by a combined exhauster and blower, with which is associated an equilibrium valve that opens and allows the excess of gas to return round the blower, thus preventing excess of pressure when the holder regulator is full.

The gas engine employed at Boulogne is one of the twin cylinder type,

capable of developing about 300 I. H. P. with side-by-side cylinders and on the Otto cycle, thus securing an impulse to the fly-wheel at every revolution. The fly-wheel is heavy, and drives a dynamo by means of a belt 15 inches wide and ½ inch thick. The engine has a special scavenging arrangement, scavenging being a great improvement when using poor gas. The cylinders are each 23¼ inches in diameter, with a stroke of 30 inches, the normal speed being 160 revolutions per minute. When developing 175 electrical H. P. the consumption of gas was 145.2 cubic feet per E. H. P.-hour, or 99.6 feet per I. H. P.-hour, the overall efficiency being 68½ per cent.

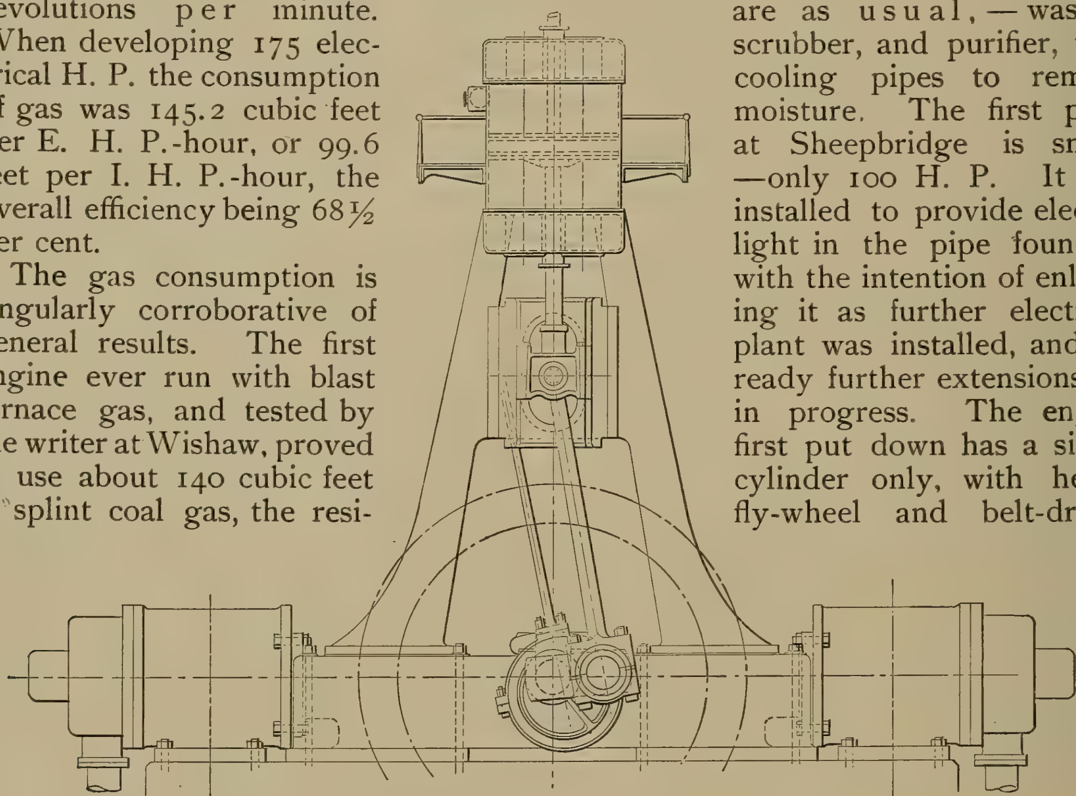
The gas consumption is singularly corroborative of general results. The first engine ever run with blast furnace gas, and tested by the writer at Wishaw, proved to use about 140 cubic feet of splint coal gas, the residuals having been removed from the gas so as to reduce it practically to the quality of coke furnace gas. The results show also how even is the efficiency of gas engines of good class working on the Otto cycle.

Another ironworks of somewhat historical renown is that of Sheepbridge, in Derbyshire. The furnaces are of the open-top, old-fashioned variety at present, but are now being modernised. The fuel is coal, with some coke, and the ore is of the oolitic class, with 12 per cent of combined water. Foundry iron is made, and the analysis of the gas by volume is as follows:—

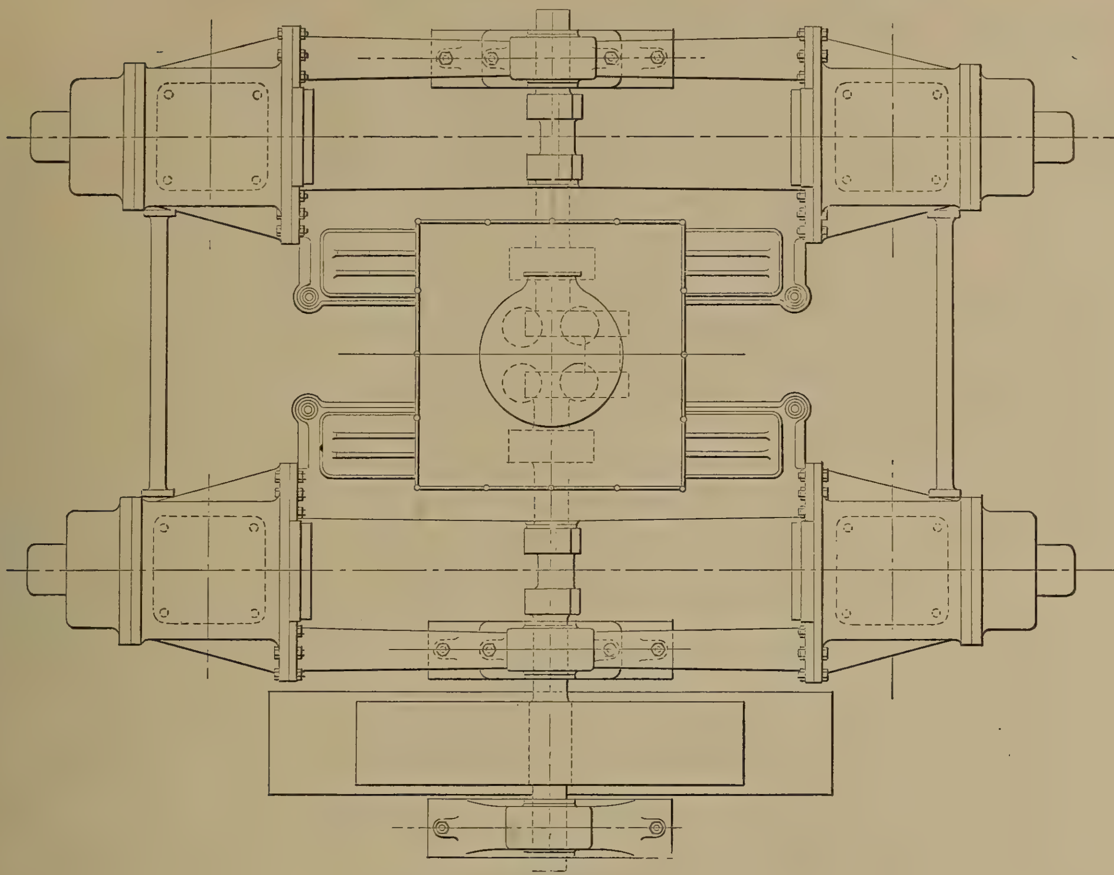
Carbonic acid, CO_2	9.0	per cent.
Carbonic oxide, CO	22.0	" "
Marsh gas CH_4	1.4	" "
Hydrogen, H	6.8	" "
Nitrogen, N	59.8	" "

As usual, about 30 per cent. of the gas is combustible, and its thermal value is 105 B. T. U. per cubic foot of gas at 60° F., again showing close uniformity in calorific value with the gas from other furnaces. The dust carried is high, and the means of removing it are as usual,—washer, scrubber, and purifier, with cooling pipes to remove moisture. The first plant at Sheepbridge is small,—only 100 H. P. It was installed to provide electric light in the pipe foundry, with the intention of enlarging it as further electrical plant was installed, and already further extensions are in progress. The engine first put down has a single cylinder only, with heavy fly-wheel and belt-driven dynamo. It has scavenging arrangement, and is attended by a regular driver, who finds no difficulty in managing it. In the engine room is a cabinet containing the pressure gauges of each piece of apparatus. The driver has thus in front of him at one glance all the gauges he requires, to know the working of the plant throughout.

As already stated, the most obvious use for the power now going to waste is, first, the production of the air blast for the furnaces themselves, and secondly, the lighting of the works and of the neighbourhood and homes in the



BLOWING ENGINE DRIVEN BY A FOUR-CYLINDER BLAST FURNACE GAS ENGINE. AN EXAMPLE OF BRITISH PRACTICE



A TOP VIEW

immediate vicinity. The production of power on an immense scale and its transmission to a distance by means of high-tension currents, as so largely carried out in the case of many American water powers, has already been frequently advocated by the author as the one great means of reducing the extravagancies of modern power production so that iron may become, if not exactly a by-product of the blast furnace, still one of its products only. But there is also a large field for power in industrial uses.

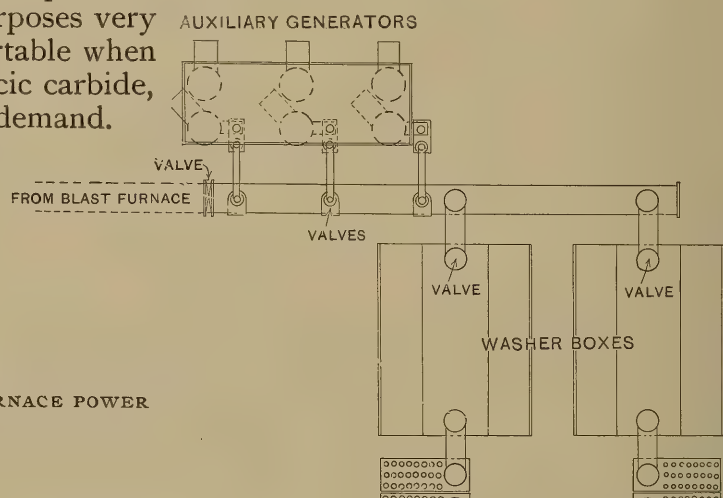
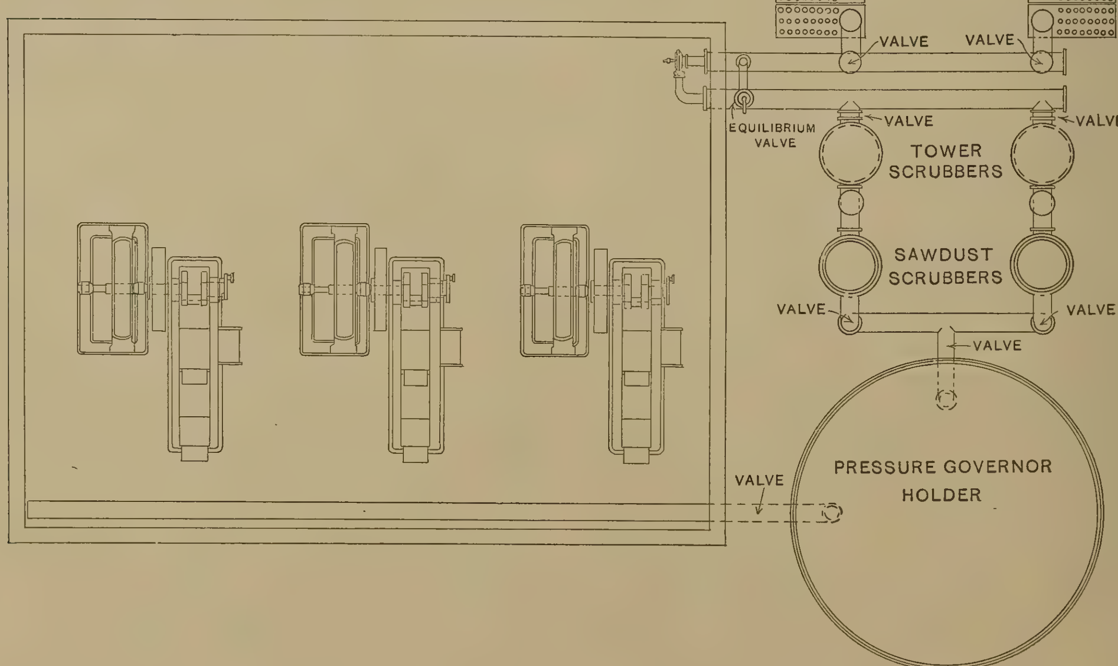
The Niagara power plant has enabled numerous works to be set up for the manufacture of electrolytic products, such as aluminium, carborundum, and calcium carbide. Already a plant has been laid down in Westphalia for the production of calcic carbide by means of blast furnace gas. In producing calcic carbide the chemical reaction is simple, and is expressed by the following formula:—$Ca\,O + 3\,C = Ca\,C_2 + CO$, or, to express this in words, lime plus carbon produces calcium carbide and carbonic oxide, the latter, curiously enough, being the same gas that is produced by the blast furnace, and awaiting only a suitable carbide furnace to enable it to do its share in driving the engine that produces it,—a cycle of operations falling short of continuity only by reason of the efficiency of human efforts and machinery falling short of unity.

It has been estimated that one pound of calcic carbide can be produced for each 2.464 electrical horse-power-hours. This power would be produced by means of 308 cubic feet of gas, of a net value of 100 B. T. U., or 30,800 heat units in all, and to produce this volume of gas 4.058 pounds of coke would be required, assuming each ton of coke to give 170,000 cubic feet of the above gas. The coke would have a capacity of 54,978 B. T. U., and would itself be the product of 6.243 pounds of coal at 14,700 B. T. U. per pound, or 91,772 B. T. U. in all. In reducing the coal to coke the difference is not lost, but

may be recovered as residuals in the shape of tar, creosote, and ammonia. From one pound of calcic carbide, as thus produced, there would be obtained 5 cubic feet of acetylene gas, with a candle power of 20 candles for twelve hours, and a calorific capacity of 7845 heat units. Thus the gas produced would actually possess no less than 25 per cent. of the calorific capacity of the gas used in the engine that produced the electrolysing current. If the 2.464 electrical horse-power were used to work arc lamps, the candle-hours would be 2464, or tenfold the light of the carbide product, while it would yield 384 candle-hours with incandescence lamps. Though the acetylene comes out lowest in candle-power-hours, it is to be remembered that acetylene is a peculiar product, and for certain purposes very safely and conveniently portable when locked up in the form of calcic carbide, for which there is a regular demand.

While manufacturing may absorb much of the electric current available from every blast furnace, there are three uses which must ultimately make larger demands than any other, namely, public and private lighting, power distribution to numerous consumers, large and small, and the electrical driving of tramways. The recent exhibition of a short length of electrical tramway driven by a gas engine, as seen at the Agricultural Hall, at London, was not necessary to prove to the intelligent that such things were possible, but was valuable as a public demonstration of that possibility, especially in face of the recently expressed opinion of one gentleman that the blast furnace could not be so employed.

The illustration given on this page represents a general plan of a power plant designed for Russia, which shows the arrangement of the purification plant,

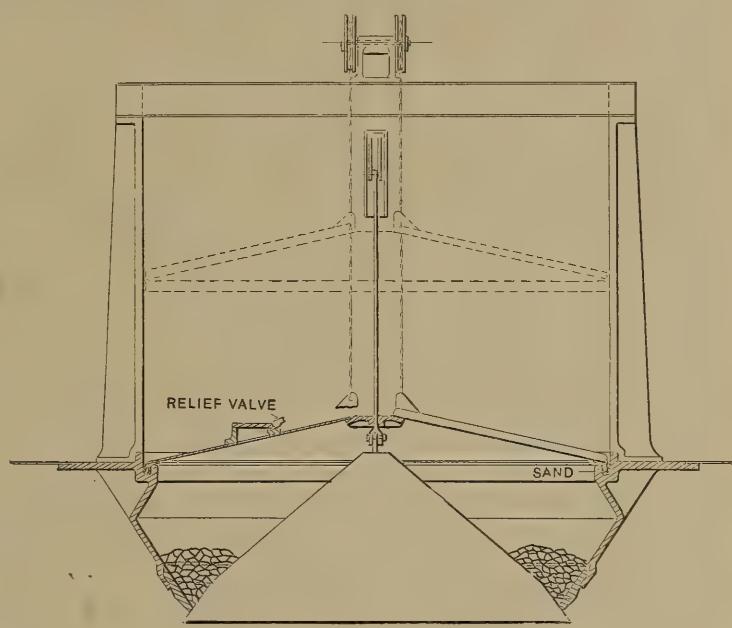
PLAN OF A RUSSIAN BLAST FURNACE POWER INSTALLATION

and also of auxiliary generating plant, which may be necessary in cases where there is but one blast furnace, as the stoppage of the furnace would upset the power arrangement. This, of course, is unlikely where there is more than one furnace. For this purpose the best design is probably that of the duplex producer, as it can be used for either coke or coal.

The points in recent practice to which attention should be more particularly directed are the furnace top and the disposition of air and gas power cylinders in the blowing engines. In British practice the air cylinder is placed in a vertical position; the gas cylinders, however, are horizontal, direct-connected, as exemplified in the illustration on page 344, and placed one on each side of the frame of the blowing cylinder. The cranks, being at 90 degrees with the air cranks, provide that the air piston is moving at maximum speed when the working pistons are on the dead point, or, what is the same thing, the maximum crank effort of the one is resisted by the maximum crank resistance of the other. This enables the fly-wheel to be much less in mass than where the tandem principle is employed. Indeed, this is well illustrated by the enormous mass found necessary in the Belgian engine exhibited at Paris. There the tandem principle was adopted, and the heavy fly-wheel became necessary.

Thus, while there is an apparent directness of action in the tandem type, this is illusive. The real direct-acting engine is that which transfers the energy of the active agent as directly as possible to the passive agent, and this is not effected by the tandem engine, for the maximum gas pressure coincides with the period of no pressure of the air instead of being so arranged as to serve to compress this at or near its maximum effort of resistance. As it is, the gas stresses go into the fly-wheel and are brought back from the wheel through all the connecting mechanism to the air piston.

The latest type of furnace head arrangement is shown on this page. There is a cover on the bell spindle which closes the furnace top when the bell is



FURNACE HEAD DETAIL

lowered and prevents the escape of gas. It is estimated in this way that a large amount of gas may be saved from waste. Tightness is assured by allowing the cover to close down upon a ring groove filled with powdered ore.

Some figures on the volume of gas produced per ton of fuel in the blast furnace may be of interest. It has been stated on good authority that about 4½ tons of air are blown into a furnace for each ton of coke consumed. This estimate is based on the assumption that the coke contains 90 per cent. of carbon, the carbonic acid produced being neglected on the ground that the extra atom of oxygen is derived from the oxide of iron in the ore. An estimate of 5 tons is, no doubt, sufficiently near for practical purposes. In most cases the temperature to which the blast is raised is about 1.000° Fahr., and to effect this the waste gases have been partially utilised in firebrick chambers, gas being burned alternately in two such chambers, while the air blast is driven by way of the other chamber, the chambers

being, in turn, heated and cooled.

Hitherto the collection of such gases has been effected in a careless manner. There is so much gas that both hot blast and steam boilers have been insufficient to use it. As a use is found for it, and its efficiency is increased sixfold by the substitution of the gas engine for the old steam plant, it is desirable to make provision to prevent any loss. Hence, the special bell cover already mentioned. It is easy to calculate the amount of heat required to raise the blast to its required temperature. Calculated from the hourly output of a furnace making 450 tons per week, the air supply will be about 27,000 pounds, and will represent about 6,400,000 British thermal units at 1000°, if the specific heat be taken at 0.2374, though at 1000° it will no doubt exceed this somewhat. The calorific capacity of the gas is practically 100 units per cubic foot.

On the assumption that the specific heat of the gas is also constant, the heat carried off by each cubic foot per degree is 0.033 B. T. U. The gases escape at 700°, and so represent 23.1 units per foot, having given up about 77 units to the brickwork. Calculation shows that, allowing 25 per cent. for various losses, about 102,000 cubic feet must be burned to supply the 6,400,000 units required to heat the blast, and the total furnace output is 455,000 cubic feet per hour. With a liberal allowance for waste, there remain, therefore, 260,000 cubic feet for power purposes, which are theoretically equal to 10,000 H. P., on the basis of 1 horse-power to 2545 units. At 28 per cent. engine efficiency, this leaves 2800 H. P., on the basis of 91 cubic feet of gas per H. P.-hour; that is, each ton of iron produced per week will give over 6 H. P. continuously generated for twenty-four hours every day. This is after making a couple of liberal allowances of 20 and 25 per cent., and practically tallies with the estimate made in the early days of the system, neglecting allowances, that each ton of iron per week would represent 10 H. P. continually.

Of the total heat of combustion of 12,000,000 units per pound of 90 per cent. coke, the sensible heat of the escaping gas represents only 6 per cent. The calorific capacity when burned represents 64 per cent., and the heat absorbed by the iron smelting process, the splitting up of ore and flux, and the heat carried off in the iron and slag represent 30 per cent. of these amounts. The first may be advantageously conserved in that portion which goes to the hot blast stoves, for it is directly useful in raising temperature and promoting ignition, but it must be dispelled by radiation or other means from the gas that is to be used for power purposes. Dry, or rather hot, gas, will naturally carry dust more readily than when the temperature has fallen low enough to render the gas moist with its own contained steam, while the attempt to use gas with much moisture would reduce the power to be obtained from the cylinder.

If a careful consideration be given to the subject, no thoughtful man can fail to be convinced that in blast furnace gas there is an immense potentiality of energy that is now going to waste, but that ought to be utilised. If Germany can make use of it, and this the Germans are now very largely doing at an enormous economy, surely the iron works of other countries cannot afford longer to run the gas practically to waste. The use of blast furnace gas never was experimental in the ordinary sense of the word, for the first genuine attempt to use it for power was a practical success, and later developments have been in details, especially of the gas engine. Large gas engines are now required; and while there has been a tendency to build them too weak in certain details, these have received due regard in some of the latest designs.

ELECTRIC POWER FOR ENGINEERING WORKSHOPS

INDIVIDUAL AND GROUP DRIVING VS. LONG LINE SHAFTING

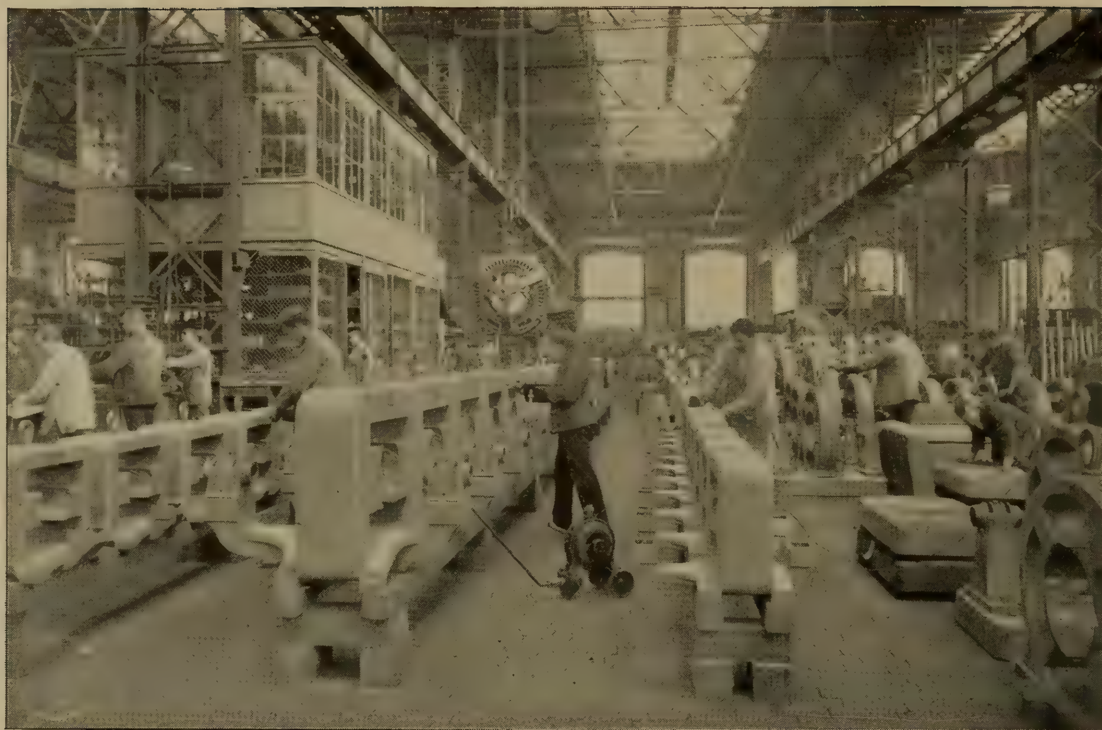
AN immense amount of material has been printed within the past few years dealing with the various applications of electric power. Papers on the subject have been contributed to engineering periodicals and to engineering societies, and, altogether, the information thus made public has been interesting and valuable in varying degrees. All of it has helped to extend the field of electric motor driving.

From a distinctly practical point of view, however, probably the most directly useful data on the subject were embodied in a report presented to the American Railway Master Mechanics' Association at its last annual meeting. This was devoted particularly to the electric driving of machine tools, and has been reprinted in full, with only slight modifications, in the following pages, together with illustrations of some of the latest forms of machine shop application of electric driving on both sides of the Atlantic. The pictures tell their own stories. While the report was made with a special view to the requirements of railway shops, it has, as will be found, a much wider range of application.—THE EDITOR.

A comparison of the relative advantages of electric and shafting driving for shop use may be made under the following general headings:—(1) Relative economy in cost of power itself. (2) Relative convenience of operation and installation. (3) Relative effect upon shop output and cost of labour.

(1) *Economy.*—This has been taken to comprehend only the relative cost of operating the two systems, including expense for fuel, attendance, repairs, interest on investment and depreciation. It is the reason most generally advanced for the installation of electric power, but can be the controlling one only where the cost of power is a large proportion of the shop running expenses. In order to compare the relative efficiencies of engine and electric transmis-

PORTABLE ELECTRIC DRILLING MACHINE, MADE BY MESSRS. MAVOR & COULSON, LTD., GLASGOW



ELECTRICALLY DRIVEN DRILLS IN THE SHOPS OF THE ALLGEMEINE ELEKTRICITÆTS GESELLSCHAFT, BERLIN

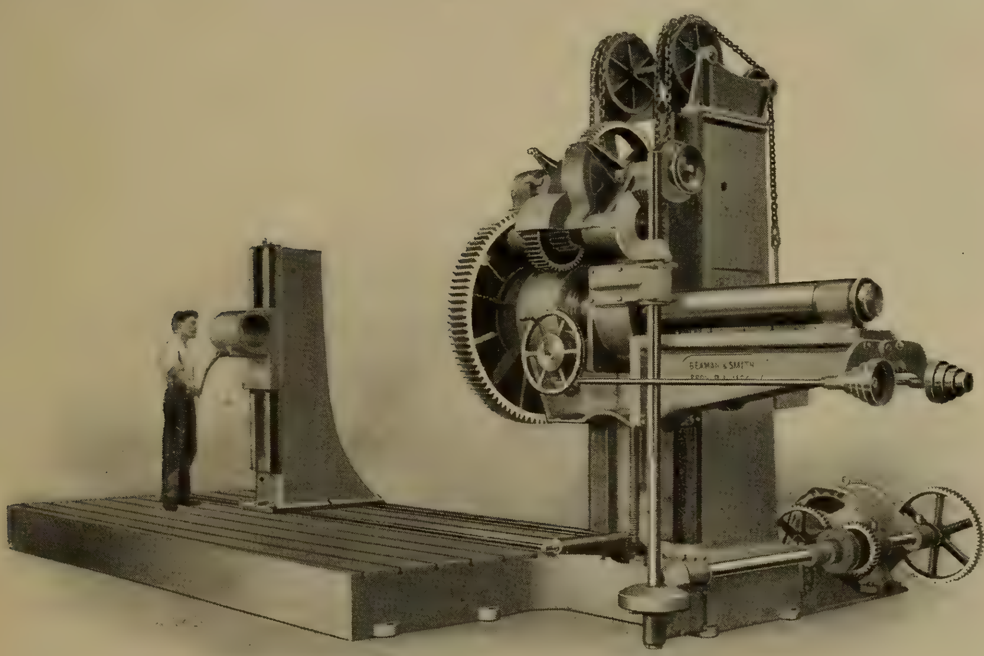
sion, it will be necessary to subdivide the character of shop plants somewhat. To do this completely would lead to endless complication, but for present purposes the typical plants are:—(1) Shop plant in which each building has its own power plant. (2) Shop plant in which all buildings are furnished with power from a central source. The manner of connection from the prime mover to the tools may be assumed, for an extreme comparison, in either of two ways, namely (*a*) shafting method; (*b*) individual tool-driving method. Taking the first condition, the average efficiency from engine to tools for steam-engine transmission is shown elsewhere to be 50 per cent.; for electric transmission, under condition (*a*) the shafting losses will be reduced by splitting up long lines and by avoiding cross belting, so that they will not exceed 20 per cent., or an efficiency of 80 per cent.; and in the electrical elements, as before shown, the efficiency from engine to shafting is 65 per cent.; therefore, the final transmission efficiency will be, $80 \times 65 = 52$ per cent., as against 50 per cent. in the purely mechanical method; or, practically, a stand-off. Under condition (*b*) much less shafting will be employed, and the electrical portion may also show a better all-day efficiency, under certain conditions, by the shutting down of idle machines,—say, a shafting efficiency of 90 per cent. and an electrical efficiency of 66 per cent., or a resultant of 60 per cent.,—showing a small gain for the electrical method. Taking the second condition and assuming an unfavourable condition for shafting transmission, as in case of a shop having each building with its own boiler plant and one or more engines, and comparing this with a case of a central power plant for electric transmission to all buildings, the possible fuel saving in the latter arrangement will result, first, from some small saving in power required for each individual building, as before shown; and secondly, from some very considerable saving due to the better efficiency of a large engine and boiler plant over that of several small ones. In extreme cases, where large condensing engines displace small non-condensing ones, and in large stations having a uniform load,

the fuel saving may readily approximate 33⅓ per cent., as is shown in an actual case cited elsewhere.

Attendance.—The item of attendance is made up of three classes of labour,—engineers and firemen; care of shafting and belting; electrical repairs. In an electric system the costs can be reduced by consolidating the engine and boiler plants and by the elimination of large and heavy belts, large shaft bearings, and the consequent danger from overheating, reducing labour probably one-half; but a new item of expense in care of electric machinery will be introduced, which will about balance the other items, leaving the whole attendance bill practically unaffected by the introduction of electric shop power in plants of any considerable size.

Repairs.—As to repairs of shafting and belting, it is difficult to obtain accurate data, the record of these items being seldom kept separately in shop accounts. The records of one large establishment have, however, been examined, and the saving found in these items, under the electric driving system, is found to be more than sufficient to pay for all repairs to motors and lines. Thus, the conclusion seems justified that the repair item will not be materially different under either system of driving.

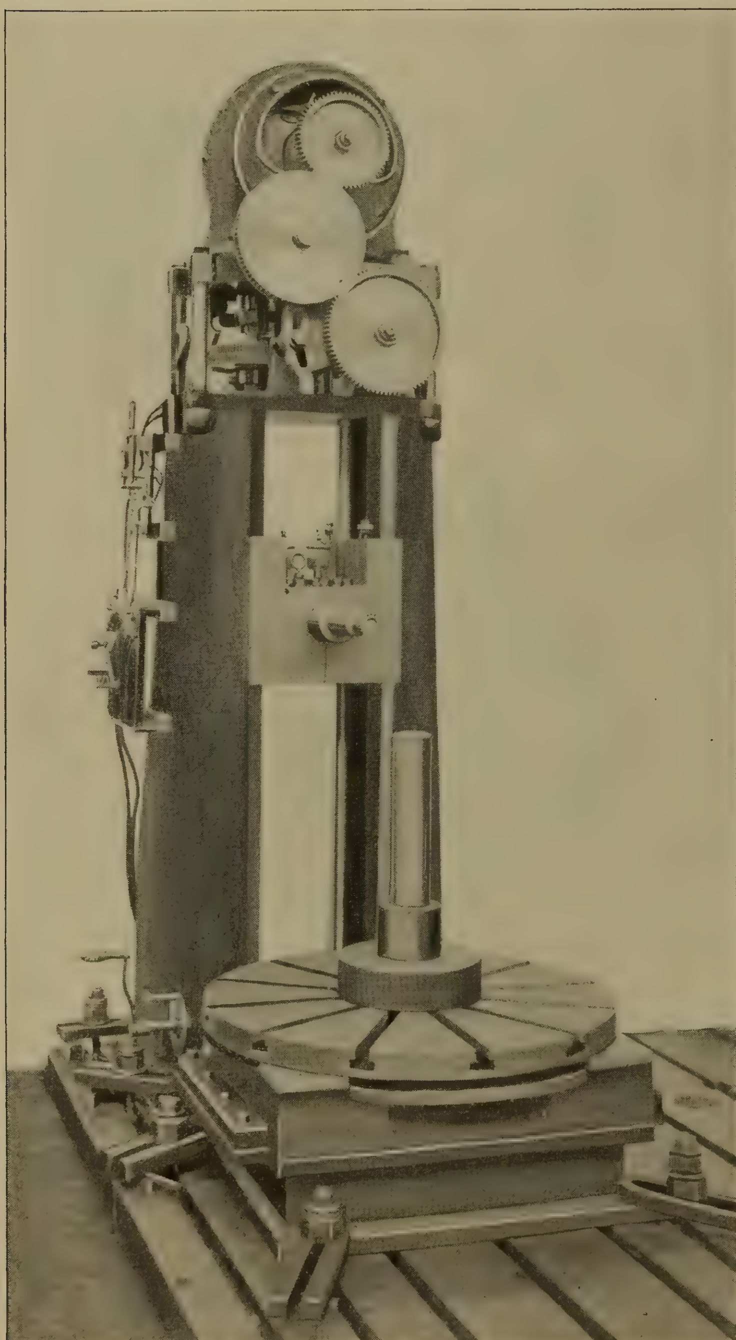
Interest—The remaining items of power cost are depreciation and interest on investment. It is difficult to institute a fair basis of comparison between the first cost of an electric and a steam transmission plant, for the reason that the results sought to be accomplished by the former provide additional shop facilities, and are, therefore, not rightly chargeable in a substitution sense. Considering, however, the case of simple substitution in a single shop, where the power plant and arrangement and number of tools are retained as before, electric driving is certain to involve a largely increased first outlay,—approximately double that for shafting method. But in a modern shop plant other considerations are the guiding ones in selection of the power system, such as the possibility of labour-saving devices, cranes, etc., and the greater cost of the electric system becomes a rightful charge against the advantages so obtained. Dropping, therefore, any attempt to draw a strict comparison between first costs, it may be said that in



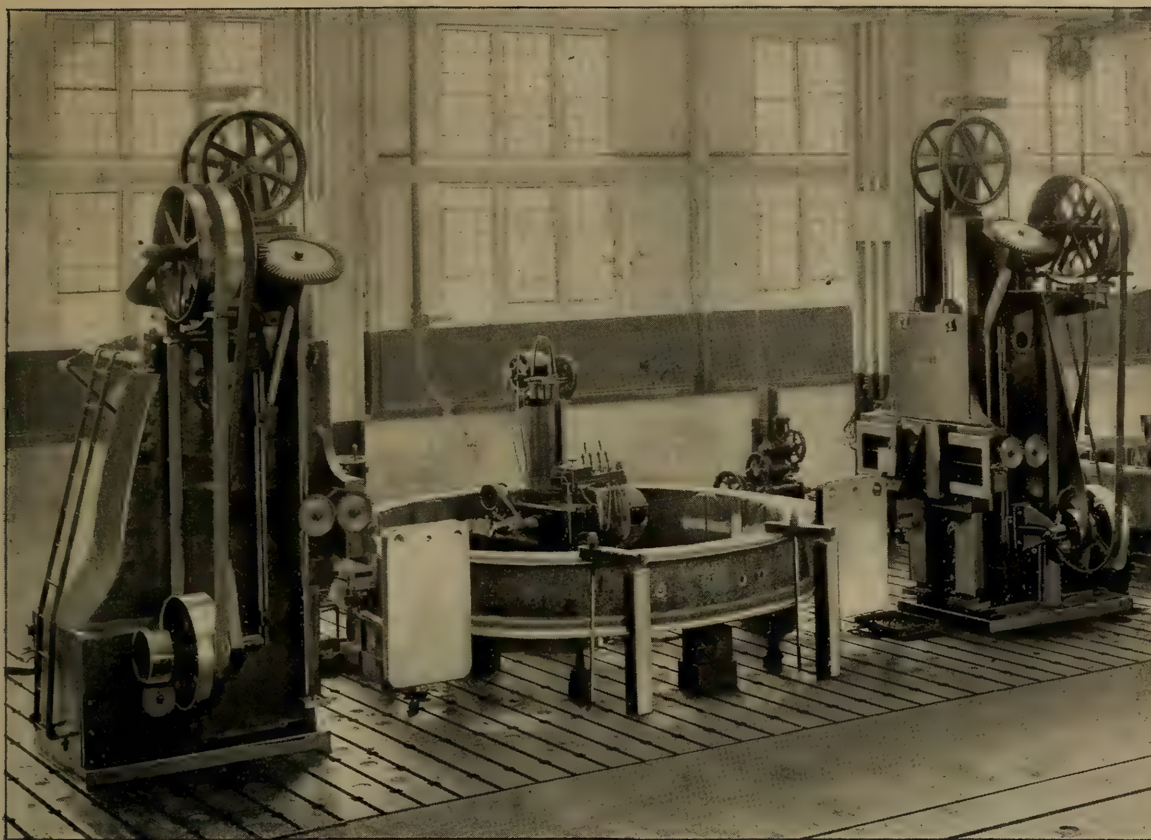
A BULLOCK MOTOR DIRECT-CONNECTED TO A BORING MILL BUILT BY MESSRS. BEAMAN & SMITH, PROVIDENCE, R. I., U. S. A.

estimating the total cost of power machinery it is usual to include an allowance for interest and for a sinking fund, with which to replace the plant when its utility is no longer on an equality with best practice. These items are generally figured together at 10 per cent. on first cost, a sum amounting, roughly, to one-fourth of the total running expenses of the power system.

Convenience and Shop Output.— These considerations are so closely inter-dependent that they can best be referred to together. The ordinary shop plant with steam power transmission, both in the arrangement of building and of machines, is the slave to the limitations of this system. It must be laid out so that the shafting and engine connection is as direct and simple as possible; the machines must be compactly arranged in parallel lines, and the ceilings and columns designed with special reference to shafting supports. In other words, the tools must be installed with first reference to the application of power, and not, as should be the case, with reference to handling the work to best advantage. Handling operations are, of necessity, largely by manual methods, and the shop buildings even must be located with first view to getting the power to them with the least awkwardness and expense. While generalising in this manner, sight has not been lost of the fact that handling and transferring machinery may be operated by other means than electricity, but it is equally true that devices of this nature are of limited practical application, and the broad fact remains that electricity is to be credited with ushering in a new era of labour-saving shop devices. Electrical transmission places no restriction on the location of the machines, and each shop may be planned with a view to handling its product with least waste of labour and with greater convenience of access to the tools. These may even be transported from place to place to the work; further, the partial or entire absense of overhead line-shafting ensures better lighting of



A PORTABLE ELECTRIC MILLING MACHINE, USED BY THE GENERAL ELECTRIC CO., SCHENECTADY, NEW YORK



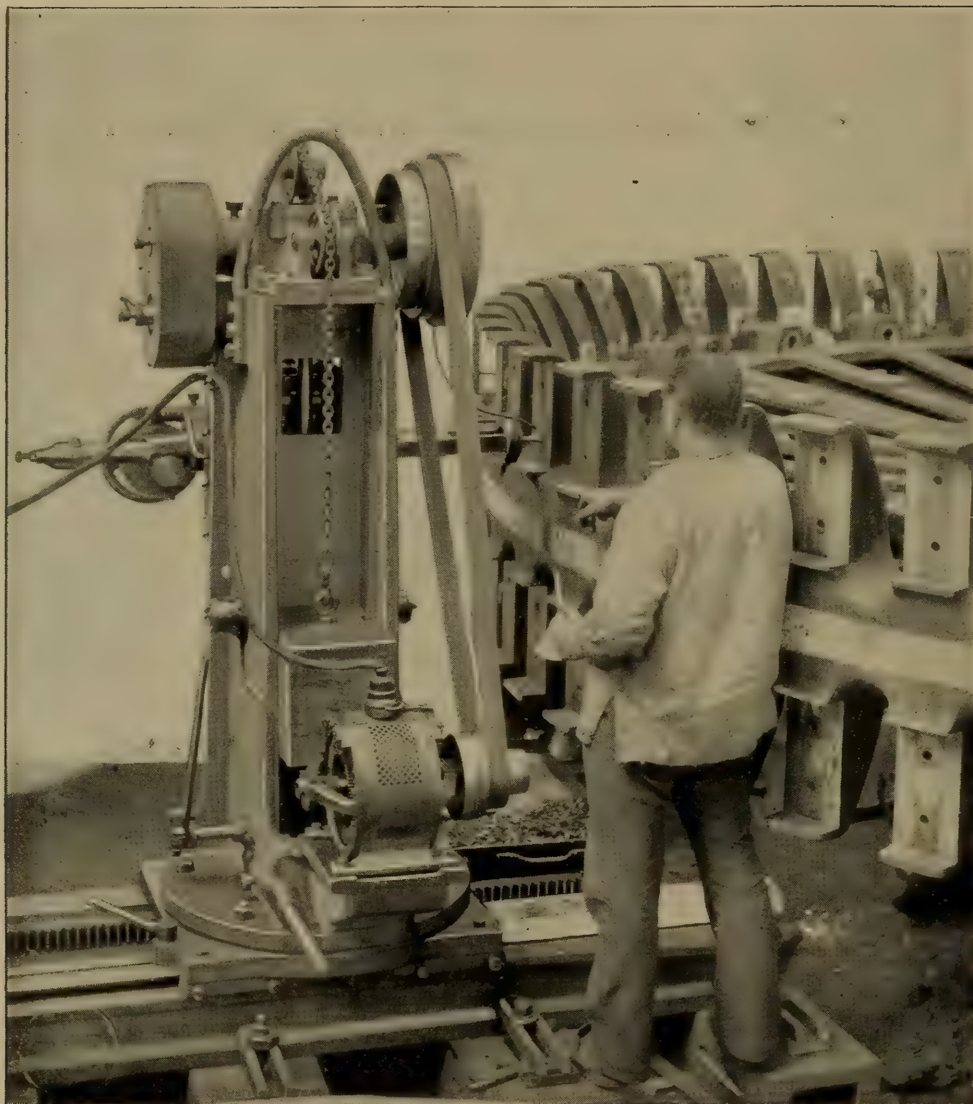
TWO PORTABLE ELECTRICALLY DRIVEN SLOTTING MACHINES AND ONE BORING MACHINE AT WORK ON AN ELECTRIC GENERATOR FIELD FRAME IN THE SHOPS OF THE GENERAL ELECTRIC COMPANY, SCHENECTADY, NEW YORK.

the shop and conduces to cleanliness. These factors promote cheerfulness and an improvement in both quantity and quality of output. The clear head room permits the universal application of various forms of travelling cranes for serving the tools and for conveying operations, furnishing the most efficient means yet developed for increasing shop economy; and, as a means of communication between buildings, electric cranes and transfer table, have advantages over appliances of the same nature driven by steam and air.

Special Appliances.—In these electricity shares a large field with compressed air. It must be admitted that air devices have, up to the present time, received most attention at the hands of the railway mechanic, a fact in large part due to the lack of practical knowledge of the electrical specialist and to the greater cheapness of air tools. With, however, the general introduction of electric shop power plants and the better acquaintance of practical men with the agency, an extensive application of electric labour-saving devices is certain to result.

Flexibility.—The extension of a shop building or the tool equipment under the shafting system is generally a matter of much difficulty, and the attempt to add to such a plant often results in inconvenient crowding of the tools, or in an overloading or complication of the shafting system, a fact which fully accounts for the extremely poor efficiency sometimes quoted for shafting transmission. In an electric system, on the other hand, great flexibility in extension is secured, as new buildings may be placed in any convenient position and additions made to the driving system without affecting the intermediate links.

Speed Control.—The ease of speed control between wide limits of certain types of electric motors is a valuable



A PORTABLE ELECTRIC BORING MACHINE USED BY THE ALLGEMEINE ELEKTRICITÆTS GESELLSCHAFT, BERLIN

feature, and will result in more frequently securing a greater adaptability of the tool to the work than is possible where a change in speed involves stopping the tool and shifting belts and gearing.

Increase in Output.—This constitutes the chief claim of electric transmission to the attention of shop managers, and it follows from the previously mentioned facts, as, by the use of electric handling devices, the tool is quickly served with its work, the product is placed in the most favourable position for operating upon, idle time is cut down, and, by independent driving, the capacity is increased by reason of the perfect control of speed possible.

POWER REQUIRED TO DRIVE MACHINE TOOLS

Data for power required for shafting, and for certain tools, may be found scattered through the transactions of various engineering societies, especially the papers of Professor Benjamin, in the "Proceedings" of the American Society of Mechanical Engineers, 1896 and 1897, which give valuable figures; but the amount of exact information attainable anywhere is not very considerable. In the nature of things, figures for frictional losses in shafting must be exceedingly variable, and under the plan of connecting the shop-power system to one main-driving engine, there is no ready means of analysing the fig-

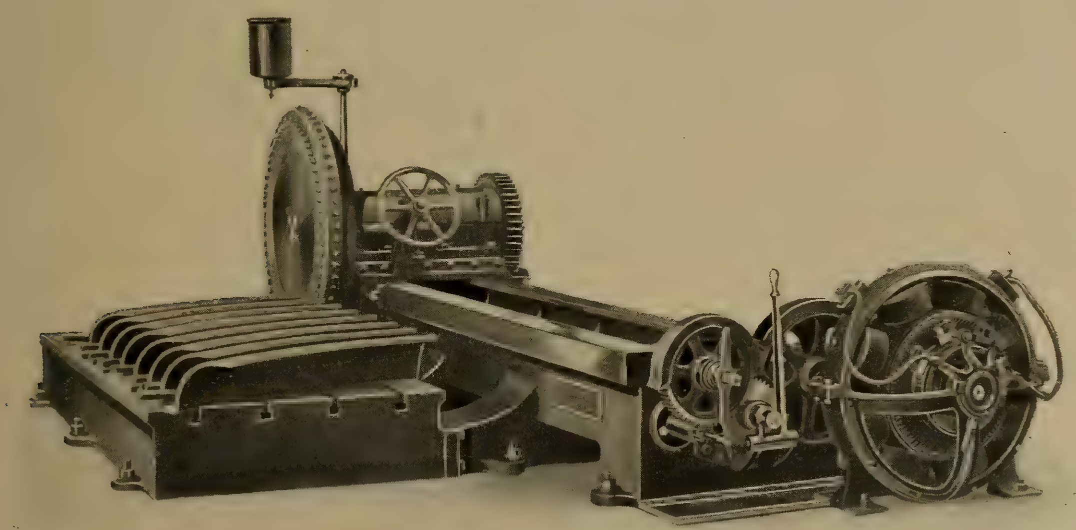
ure of engine-indicated horse-power to determine the consumption of any particular section of shaft or of a single tool. With the introduction of electric driving, however, the subject is becoming better understood, as it is a simple matter to connect a test motor to a shaft or tool, and thus obtain figures from which to design a power plant for maximum efficiency.

Electric Efficiency.—An electric transmission plant varies in efficiency as follows:—

	Per cent
Generators	86 to 90
Transmission lines	90 " 95
Motors	78 " 90
Total final efficiency	62 " 77

The above are figures for full loads on the different elements, and the variation arises from the difference in sizes of units employed and in line losses assumed. At partial loads the machine efficiencies will drop, but the line efficiency will increase, so that the resultant will be nearly independent of the load. In fact, it is generally possible to shut down many of the separate motors when operating the plant at partial load, and the efficiency of transmission may thus actually increase under such conditions. In an average size of railway shop plant a resultant all-day efficiency of 65 per cent. from the engine to the motor pulley may be assumed.

Shafting Efficiency.—The average friction horse-power in heavy machinery shops to drive belts and shafting, from engine to tool pulleys, as given by various authorities, varies from 40 to 55 per cent. of the total power used, and perhaps the round figure of 50 per cent. is as near the correct general average as the data will permit. Considering a separate shaft only, with compactly arranged tools, a better efficiency than the above can be assumed, and, judging from a number of experiments with electrically-driven line shafts, 20 per cent. fairly represents the average loss in shaft and countershaft bearings and belts on the tools, or an efficiency of 80 per cent. Some authorities attempt to express the actual horse-power lost in friction per 100-foot length of shafting, and per countershaft and per belt; but while figures of this kind would be useful if approximately correct even, it was impossible to check them closely enough to feel warranted in quoting them. As a rough guide in laying down shop power plants, it would appear that the horse-power of generating station required per man for railway shops will average about 0.4 horse-power. Table No. 1 gives a few examples from tests of the power required to drive typical railway shop tools, both for iron and woodworking. The greater number of these results for metal-working tools



AN ELECTRICALLY DRIVEN ROTARY PLANER IN THE GENERAL ELECTRIC COMPANY'S SHOPS AT SCHENECTADY, NEW YORK

were taken from tests at the Baldwin Locomotive Works, and for woodworking tools from Pennsylvania Railroad Company tests.

SUGGESTIONS UPON THE MANNER OF INSTALLING AN ELECTRIC TRANSMISSION PLANT

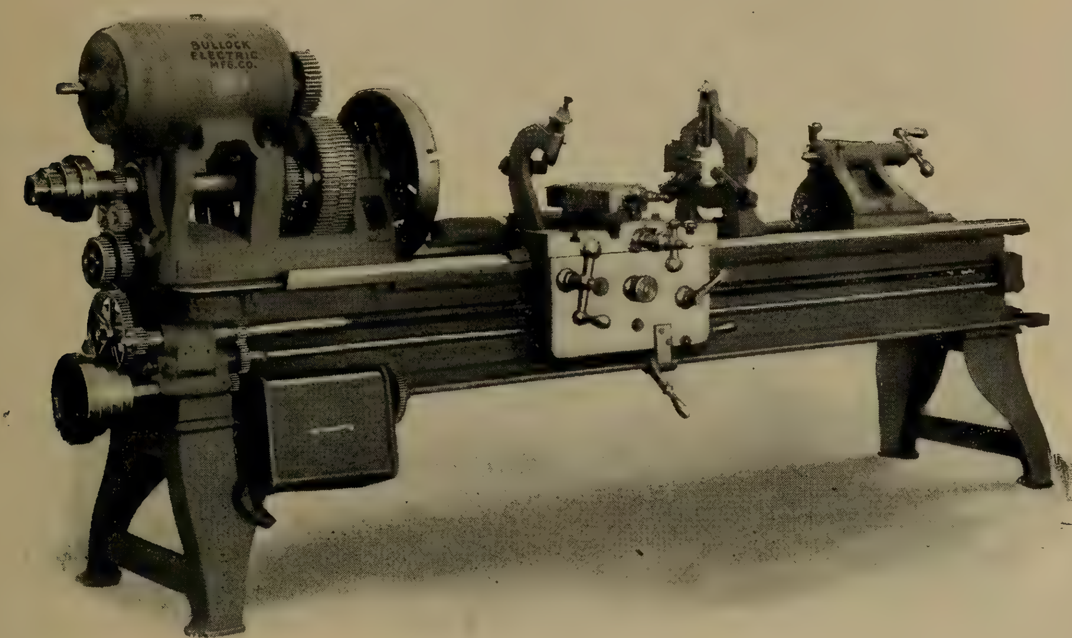
System.—Both direct and polyphase alternating current systems are applicable for shop use, and each system has its advocates among electrical engineers. For long-distance transmission, say, one mile or more, alternating transmission is almost a necessity; for shorter distances, and in cases of isolated plants in compactly-grouped railway shops, the direct-current system can be employed without any practical disadvantages in waste of power in transmission lines. Mechanically, the induction type of alternating motor has great advantages in its simplicity and the absence of rubbing contacts. When it is said that probably 90 per cent. of all direct-current motor repairs are to commutators and brushes, the importance of this statement is clear. A further advantage in the induction motor is the strong mechanical design of the revolving element. This is built up of heavy copper bars firmly bolted to a cast centre. The direct-current motor, on the other hand, is a complicated assemblage of small wires, made additionally weak by the necessities of installation. The disadvantages of the alternating-current motor are its high speed, and the fact that it is essentially a constant speed machine. For driving line shafting, a constant speed motor is entirely satisfactory, but for independent tool driving a variable speed motor has unquestionable advantages. If the alternating system is to be adopted, it is important to specify that the motors shall be of the "induction" type, as this is the only variety which is at all applicable to shop uses. A further element of importance in the alternating system is that of "frequency" or number of alternations of the current per minute. It is difficult to give a positive recommendation as to the proper frequency without qualifications. Realising, however, the importance of standardising apparatus, the committee venture to suggest the specification of "3000 al-

TABLE No. 1—POWER REQUIRED FOR MACHINE TOOLS

Tool.	Nature of Work.	H.-P. Required: Empty	Light Load	Full Load	No. of Cutters	Remarks
70 in. wheel lathe	32 in. wheel centre	- --	4.7	5 8	2	½ in. deep cut.
	56 in. wheel centre	1.5	5.2	6.2	2	
Horizontal lathe	56 in. wheel centre	----	4.3	7 1	1	½ in. deep cut.
Large double frame planer	Two frames	11.0	----	21.6	2	½ in. deep cut.
Slotter, 18 in. stroke	Frames	2.3	5.0	10.3	1	Heay cut
Slotter, 12th stroke	Wrought iron, 6 in. thick	1.5	2.1	6.5	1	
36 in. planer	Frames	3.4	4.2	7.4	1	
		3.4	----	11.3	2	
Drill press	1 in. drill, wrought iron	.97	1.94	2.9	1	
	1½ in. drill, wrought iron	.97	1 92	2.2	1	
	2¼ in. drill, wrought iron	.97	1.94	2.85	1	
Boiler-plate shears	9-16 in. plate steel	3.5	6.0	19.0	1	
Boiler-plate rolls	11-16 in. by 10 ft. 6 in. long, steel	4.5	14.4	19.8	--	
Jib crane, 10 ton, 10 H.-P. motor	Lifting 10 tons	1.2	----	13.0	--	
	Lifting 7 tons	1.2	----	11.0	--	
Jib crane, 6 ton, 8 H.-P. motor	Lifting 6 tons	1.2	----	11.6	--	
Travelling crane, 5 ton	Lifting and carrying 4 tons	11.9	----	19.3	--	
Planer	Empty	3.4	----	--	--	
	1 tool	----	----	7.4	--	
	2 tools	----	----	14.0	--	
Shafting	Empty	15.0	----	----	--	
	6 planers	----	----	20.0	--	
	4 milling machines	----	----	26 0	--	
	2 lathes	----	. . .	30.0	--	
	1 buff wheel	----	----	34.0	--	
Planer and siding machine	6 in. oak flooring	8.0	----	32.0	--	Top and sides planed
24 in. planer	12 in. yellow pine	2.5	----	11.0	--	Top only
Moulding machine	6½ in. yellow pine carlin	1.5	- --	8.5	--	Four sides
Daniel 30 in. head planer	Oak tender end sill	3.7	----	8.8	--	Cut 3-16 in. off top
3-spindle boring mill	Oak, 2 in. bits	0.5	----	2.5	--	
Large tenoning machine	Oak, end sills	3.0	----	7.0	--	3¾ in. by 5 in. by 10 in. cut.
Circular rip saw, 28 in. diam	Oak, 9¼ in. by ¼ in cut	1.5	----	20.0	--	
Band saw blade, 1½ in. wide	Oak, 12 in thick.	1.5	----	6.0	--	

ternations per minute'' for adoption in railway shop plants. Alternating motors of this frequency are now in general use, and have the very great advantage of fairly slow speed.

generator is more compact and more solid in construction, especially in small machines, due to the greater size of its parts. It is, therefore, more durable and somewhat more efficient on account

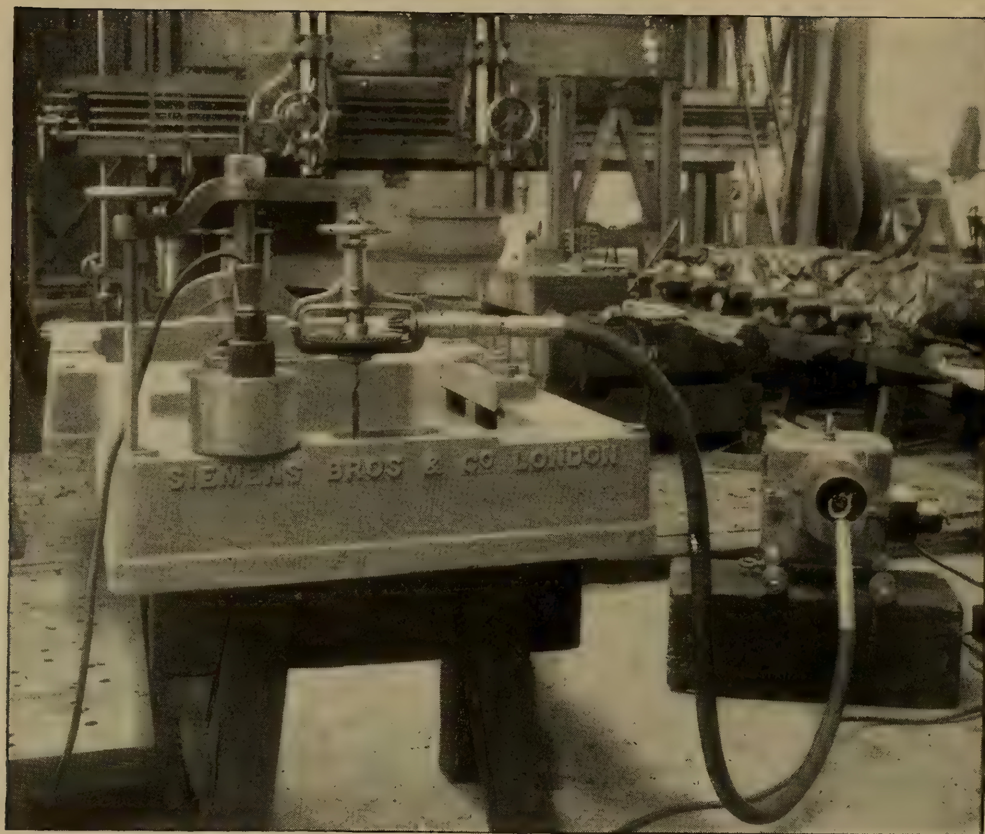


AN ELECTRICALLY DRIVEN 18-INCH LATHE, BUILT BY THE R. K. LE BLOND MACHINE TOOL CO., CINCINNATI, U. S. A. MOTOR BUILT BY THE BULLOCK ELECTRIC MFG. CO., OF CINCINNATI

Voltage —Direct-current generators are built for 125, 250, and 550 volts pressure, which, allowing for ordinary losses in lines, correspond to motor pressures of 110, 220, and 500 volts, respectively. The 220-volt, direct-current motor is practically the standard for shop purposes; the 550-volt motor is used for railway purposes, but this pressure is undesirably high for shop use. Incandescent lamps may be obtained for 220-volt circuits, or the more common 110-volt lamp may be used on such circuits by connecting two of them in series. A 250-volt generator, together with 220 volt motors, are, therefore, recommended for shop plants. Alternating-current motors are wound for either 220 to 440, and for similar reasons to the above the 220-volt system is recommended.

Type and Size of Generator.—As between the direct-connected and belted machines the relative advantages may be thus stated:—The direct-connected

of elimination of frictional losses in belting. The belted generator has an advantage of cheapness in first cost, due to its higher speed, which means more output for the same amount of material; and a further fact, often of importance, is its ready applicability to existing engine plants. For generators of 75 horse-power or less, the belted machine answers every practical purpose, but above this size the purchase of direct-connected machines will be found an economy in all new plants. In planning the installation of a transmission plant with small beginnings for running, say, one electric travelling crane, transfer table, turn-table outfit, and a few portable tools, a 75 or 100 horse-power belted generator will be found a convenient unit size. It may be installed cheaply by belting from countershaft at the main shop engine, but it is altogether better to provide a separate engine, for the reasons that the electric drive may be needed twenty-four hours



A PORTABLE DRILL DRIVEN ELECTRICALLY THROUGH A FLEXIBLE SHAFT, EQUIPPED BY MESSRS. SIEMENS BROS. & CO. LTD., LONDON

in the day for special work,—such as operating a roundhouse turn-table,—and it makes a good emergency power plant for portions of the shops working overtime. It may be also used at night to light the roundhouse and other buildings. When the transmission plant outgrows the capacity of this generator, it may still be used as a "spare," or for overtime work.

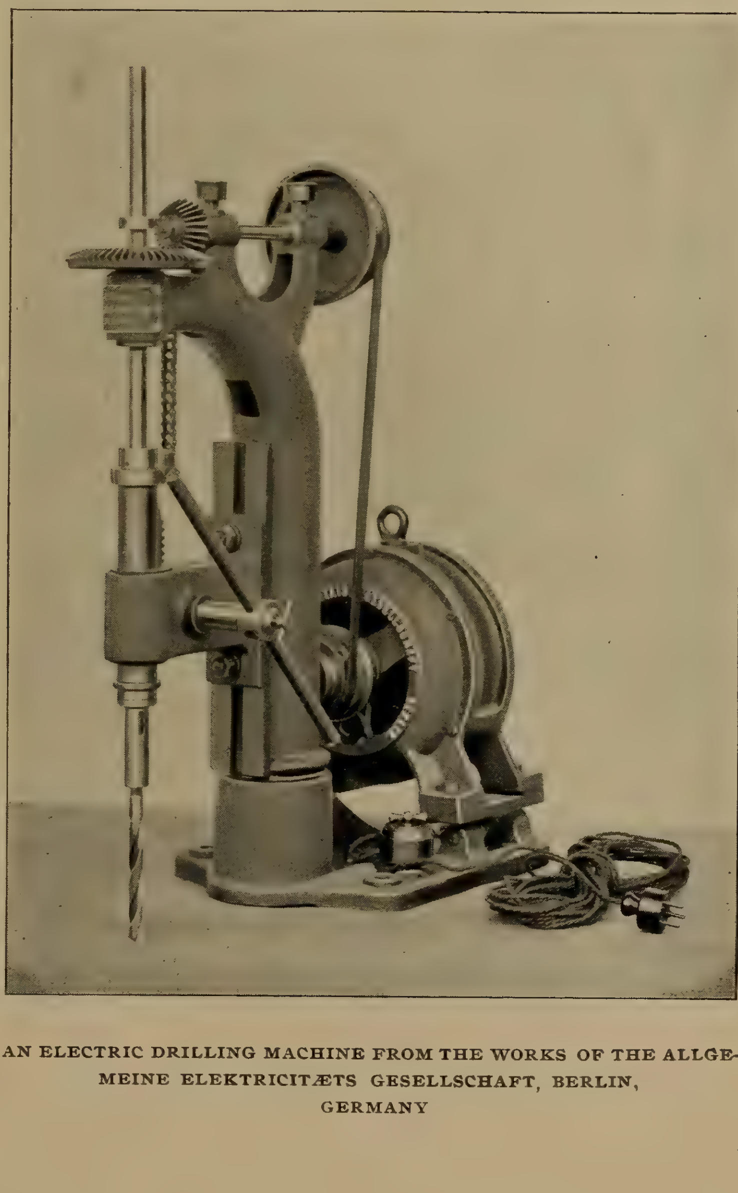
In laying out a complete system of electric transmission to displace engine and shafting transmission, careful attention should, of course, be given to selection of unit sizes. Little advice can be given offhand for such a case, as the determination of average and maximum loads is the basis of all calculations. In large plants, say, of 500 horse-power or over, there should be two, and possibly three, units of the direct-connected type, and selected so that the engines shall run as far as possible at economical loads, and that one unit may be out of service for repairs. Calculation of generator capacity required can be made approximately from published data on power required to run machine tools. It is usual to install motors having a considerably larger nominal capacity than figured requirements, so that generator capacity need never be as great as the added capacities of motors attached. In fact, the generator load in an ordinary shop seldom runs above 50 per cent. of that of the combined motor capacity, and in shops having a large motor load the effect on a generator of running a travelling crane, a transfer table, and turn-table need not be considered, as the momentary overload capacity of the machine will be ample to take care of such requirements.

Rating of Generators.—Generators are sold with a guarantee to deliver their rated capacity, when driven at a certain speed, indefinitely, with a maximum temperature rise, due to electrical losses, of an amount supposed not to be injurious to insulation. This rise should not exceed 40 degrees C. above the temperature of the surrounding air. They are also guaranteed to carry an overload of 25 to 50 per cent. for two

hours, and short-period overloads of 100 per cent. without injurious heating. These guarantees have led to an objectionable but common practice of figuring the engine size on the overload capacities; that is, it is quite customary to couple a generator to an engine having its economical rated capacity equal to the 50 per cent. overload capacity of the generator. The consequence is that load is piled on the generator as long as the engine will pull it without seriously dropping off in speed, and an expensive generator is finally ruined for lack of the common sense precaution which would be furnished by a properly adjusted engine unit.

Motors.—If the direct-current system be adopted, a wide range of selection in motor types is possible. For line shafting, motors should be of the shunt type. For individual tool driving, the shunt motor is also in most common use; but the compound-wound, variable speed motor is recommended as a desirable substitute. In fact, it is the belief of the committee that one of the great advantages of electric driving is in the possibility of simple speed regulation for large tools, and the attention of the electrical companies should be called to the importance of filling this requirement in their line of standard motors. Motors are preferably of "open" construction; that is, with the ends of the field frame uncovered. Where exposed to the wet or to mechanical injury from articles falling into it, the closed type of motor may be employed, but this type is not desirable where it can be avoided, on account of its lack of ventilation, which means overheating, unless the motor is of relatively large size for the work to be done. For travelling cranes, hoists, transfer tables, locomotive turn-tables, and boiler-shop plate rolls, which start under load run at variable speed, stop, and reverse, the series-wound motor is the best, and is preferably of the enclosed style, which allows of more universal connection in any position, by gearing or otherwise, than the open type, and the question of heating is not so serious, on account of intermittent running. For alternating motors, the same considerations as for the "direct" apply; but, as elsewhere explained, variable speed running in this type for tool-driving motors is not practicable. For crane work, however, the induction motor is successfully applied by attaching special controlling devices.

In selecting motors, the importance of keeping down the number of sizes should be had in mind. This should



AN ELECTRIC DRILLING MACHINE FROM THE WORKS OF THE ALLGEMEINE ELEKTRICITÆTS GESELLSCHAFT, BERLIN, GERMANY

be done at the expense of some increase in first cost, and in spite of some waste of power due to reduced efficiency of underloaded motors, especially as their reliability is thereby enhanced. Competition among the makers of cheaper grades of motors has resulted in giving ratings dangerously close to the maximum safe working limit, and with all motors a reduction in the working load greatly increases their durability. In deciding upon the make of motor to be purchased, there is the same range for selection as found in other lines of machinery; but as an electric motor is a somewhat delicate machine, it is important to select only those made by reliable manufacturers. Such can be had of several companies, but they are not the lowest in first cost, and, in absence of definite information, it is generally safest to avoid very cheap machines. Even the best manufacturers make motors with different ratings as to speed and heating limits, and the lowest speed and lowest heating limit motors should be selected. This latter should not exceed 40 degrees C. rise above external temperature at continuous full-load run. The speed should be the so-called "slow-speed" variety. Table No. II. gives about the proper speed for each of the standard sizes of shunt motors. It also gives the approximate selling prices of the list, based upon the highest grade machines; price includes motor with pulley, base frame, and belt tightener, and starting box. A corresponding list of "medium-speed" motors may be obtained, the speed for a given power being about 50 per cent. higher than given in the table, the prices being about 20 per cent. less on smaller and 35 per cent. less on larger sizes.

TABLE NO. II.—SPEED AND PRICES OF SLOW-SPEED DIRECT-CURRENT MULTIPOLAR MOTORS

Rated output, H. P.	Speed, R. P. M.	Price Dols.	Price per H. P. Dols.
2	1000	135	67
3½	1050	190	55
5	950	240	48
7½	850	310	41
10	750	400	40
15	650	500	33
20	600	600	30
30	575	850	28
40	550	1050	26
50	550	1200	24

Manner of Tool Driving.—This varies in accordance with the motor arrangement, and may be by (*a*) the group system; (*b*) the individual system. The selection of one or the other system depends upon the size of the tools and the consideration of intermittent or continuous running. In general, where the tools require less than 3 horse-power each, it is best to drive them in groups from short-line shafts, which, as a rule, should not require more than 25 horse-power per shaft group. Where, however, 3 horse-power or over is required, or where variable speed or intermittent running is desirable, each tool should have its own motor. In the group system the motor may be either belted to or direct connected on the end of the line shaft, accordingly as space or plant cost permits. In individual driving either belted or geared motors are employed. The belted arrangement is somewhat clumsy, but reduces shock and prolongs the life of the motor, and is, in the opinion of the committee, the better arrangement for general use.

Conclusions.—(1) In a small shop, consisting of practically one building, having an equipment of small tools for light work only, electric transmission will not be found a paying investment. In such a shop, however, an electric lighting dynamo will be a convenience, and may be utilised to run a few labour-saving electric tools, such as a cylinder-boring outfit, a turn-table motor, etc. (2) In an extensive railway shop plant the installation of a central power station and electric transmission will always be found advisable, as it will not only result in the most economical system in respect to operation, but will make possible far more important shop economies, namely, an increase in quantity and quality of output and a reduction in cost of handling the same.

DESCRIPTION OF ELECTRIC TRANSMISSION SYSTEMS

Power may be distributed by either of two electrical methods:—First, by "direct" or "continuous" current, which means a flow of current in one

direction along a wire; secondly, by "alternating" current, or a reciprocating flow analogous to the to-and-fro movement of an enging piston. Both of these systems are in general use for power and lighting purposes. The development of alternating-current apparatus is a consequence of the limitations of the direct-current system when applied to long-distance transmission, these limitations arising from the great cost of the large conductors needed to carry the low-pressure current, which is a necessary accompaniment of direct-current transmission. In the alternating system, on the other hand, electricity may be generated and transmitted at high pressure, and consequently small volume, over a small line wire and transformed at the place of use by a simple piece of apparatus into current of low pressure and large volume. The main elements of an electrical transmission system are:—First, the generator or dynamo, which produces electrical energy from mechanical; second, the transmission wire for carrying the current; third, motors for converting electrical into mechanical energy at the points where it is to be used.

The Generator.—This piece of apparatus is, in general appearance, probably familiar to all. It consists of a stationary part with bearings, and a revolving part, the shaft of which is connected to the source of power. One of these parts constitutes the "field," and is provided with magnet poles, while the other constitutes the armature in which the currents are induced by the rotative movement of its wires in the strong magnetic field. Generators may be either of the "belted" or the "direct-connected" type, in accordance with their method of coupling to the engine shaft. The latter method is rapidly superseding the former for machines of 75 horse-power and larger, as the type has many mechanical advantages over the belted machine. The size of a generator is expressed in terms of its electrical output in "watts," an expression meaning the product of the volts pressure by the number of ampères of the current. As, however, a watt is an inconveniently small unit, it is customary to rate machines in a multiple called a "kilowatt" (KW), which is 1000 watts, or about 1⅓ horse-power.

Generators are further classified by the character of the current furnished into "direct-current" and "alternating" types. They are similar in appearance, but differ in the important particular that a direct-current generator is provided with a commutator and brushes for rectifying the alternating current produced in the armature, while the alternating generator needs no such device, the current being taken off from continuous collector-rings. An alternating generator requires, however, that its magnets be supplied with continuous current; this is usually done from a small separate machine, called an exciter.

Alternating-current generators are further subdivided into "single-phase" or "multiphase," terms which refer to the kind of alternating current produced. This can best be explained by a mechanical analogy:—An engine shaft may be driven by a simple crank, or by two or more cranks set at, say, 90 degrees or 120 degrees, the turning moments at each crank rising, falling, and reversing in succession. In the same way alternating currents may act in a simple wave or in several waves acting successively. The advantages of multiphase-current apparatus lie in the peculiar properties of motors which are possible with the system. Generators are provided with a switchboard, usually a marble or slate panel, on which are mounted safety devices, measuring instruments, and switches for electrically connecting them with the various lines of wire leading to the points at which the current is to be utilised.

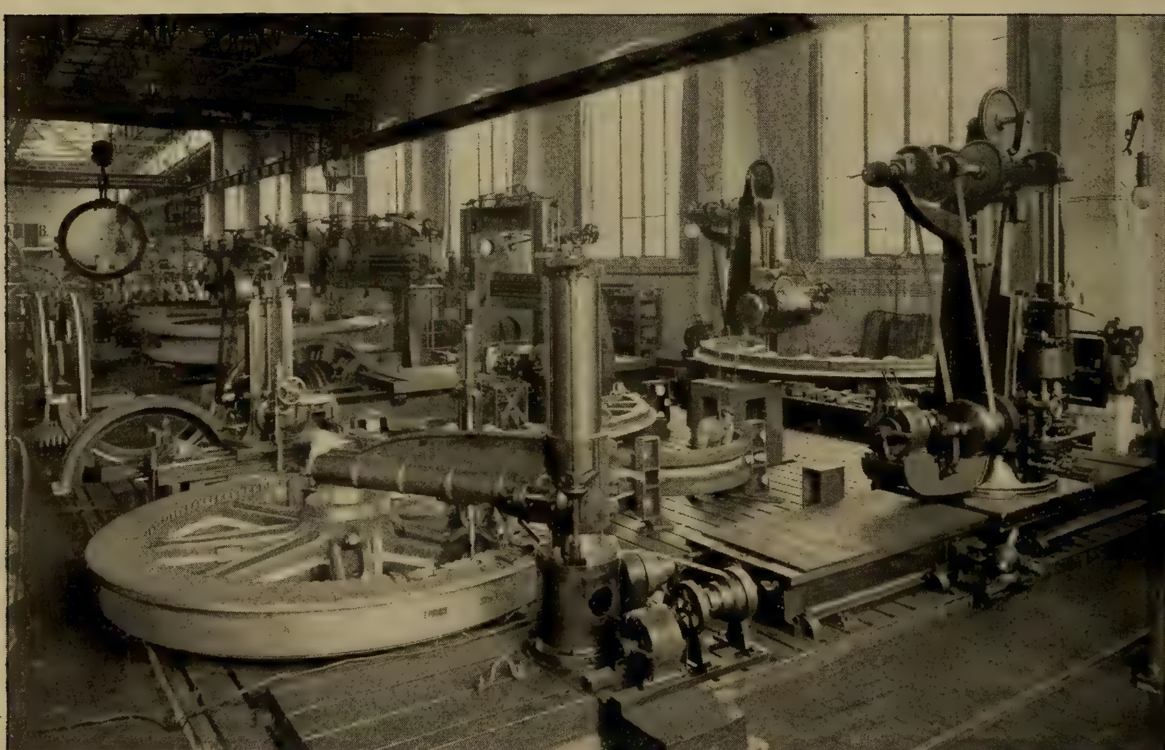
The Line.—The line consists of wires of different sizes or current-carrying capacities. These wires are covered with an insulating compound, and must be carefully laid out and erected under competent supervision, in order to ensure safety from fire and to avoid waste of power. It is essential that no considerable changes should be made either in the location of the motors or lights

until the effect upon the distributing system is figured. The materials to be used and the manner of running the distributing lines are thoroughly covered by printed rules issued by the electrical societies and by the Board of Fire Underwriters, and an inspection certificate by the expert of the local board is desirable as an insurance against bad work and as evidence in case of fire.

The size of the wires is determined by two main considerations:—First, the safe heating limit with the amount of current to be carried; and second, the loss of power entailed by the heating. The heating limits for different size wires are given in printed authorities, but the permissible drop of pressure or loss to be allowed within the heating limits is the matter to be determined by the individual. If this drop of pressure is made very large the loss of power is great, and the cost of fuel accordingly increased; but the investment in copper conductors is small, and *vice versa*. As, however, an excessive loss interferes with uniformity of pressure in various parts of the distributing system, it is seldom advisable to allow more than 10 per cent. drop from the generator to the motor, which means that 10 per cent. of the current generated is lost in heat in the wiring system.

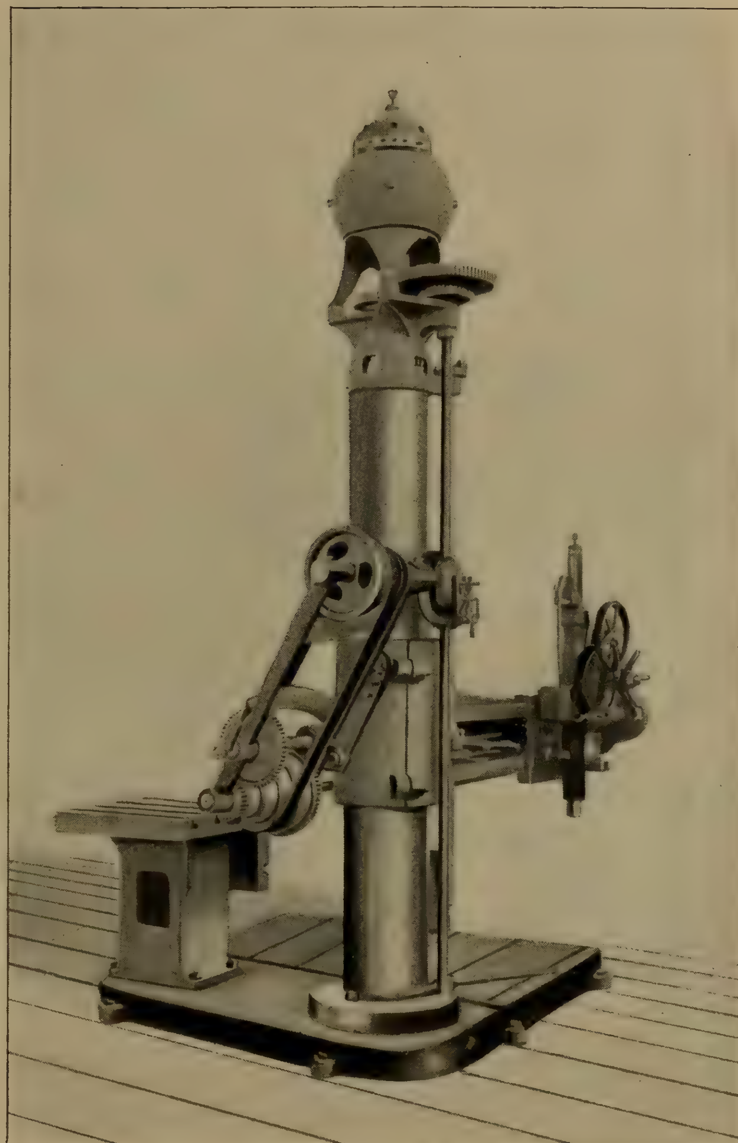
The rules for laying out a distributing system, for either direct or alternating current, are the same: but the alternating-current distribution involves more complication than direct current, thus:—In the direct system two wires constitute a feeder line, namely, the outgoing and the return; in the polyphase alternating system, which is generally used for power work, either three or four wires are needed for each feeder line. If a change in pressure of the alternating current is required, an additional piece of apparatus, called a "transformer," is inserted in each feeder line. This device is permanently placed in a sealed iron box, outside of the building, or in such place that the high-tension wiring is entirely out of reach of accidental handling. It has no moving parts, and needs no inspection, except in case of accident.

The Motor.—An electric motor is a generator with the operations reversed, and both are of similar construction,



ELECTRIC RADIAL DRILLING MACHINES IN THE SHOPS OF THE ALLGEMEINE ELEKTRICITÆTS GESELLSCHAFT, BERLIN

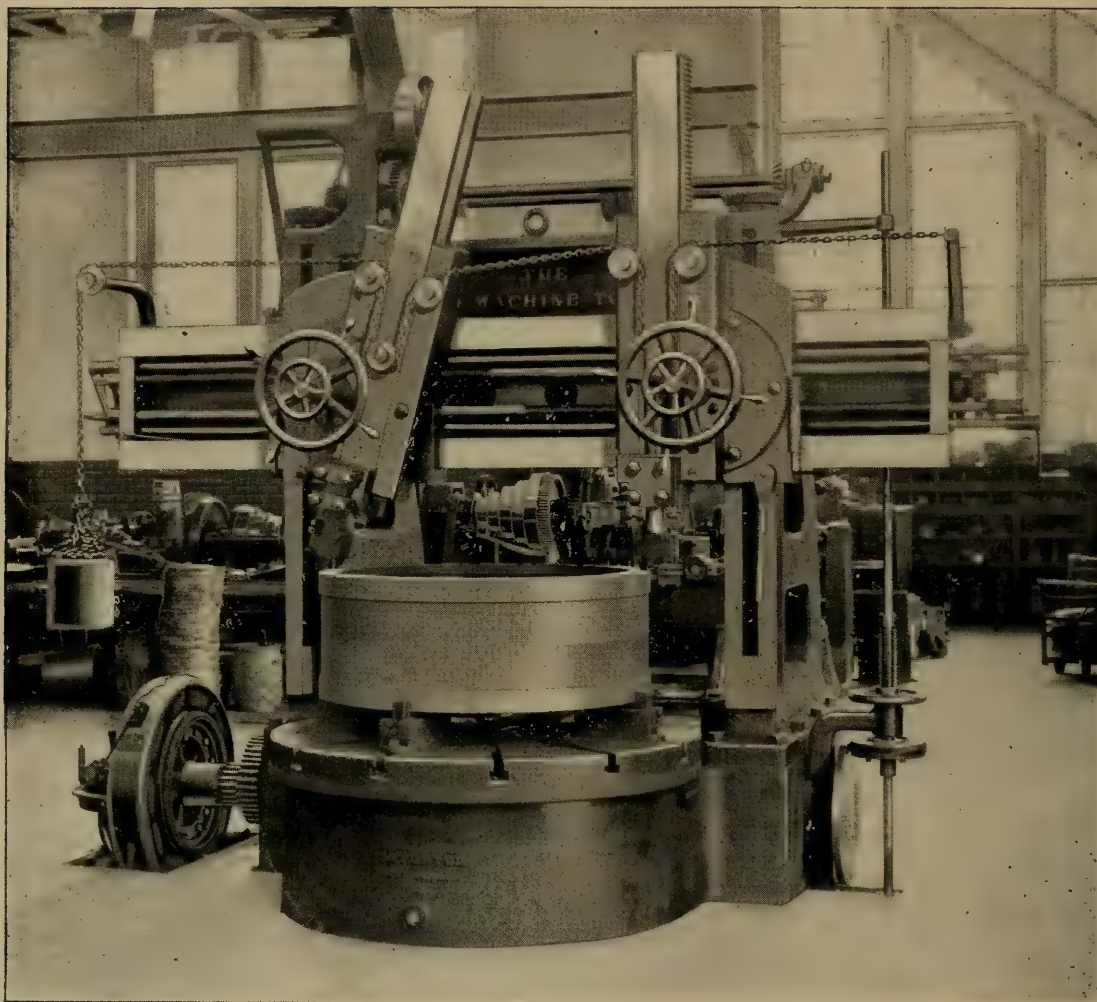
electrically and mechanically. It may be used interchangeably as a generator, although a slight modification is desirable in so doing. It converts electrical energy into mechanical by means of magnetic attractions or pulls. Motors are divided, as in the case of generators, into the alternating and the direct types. These may be similar in general appearance, and both have the same main elements, namely, a stationary and a revolving portion, constituting the field and the armature, respectively.



A NILES RADIAL DRILL EQUIPPED WITH A VERTICAL ELECTRIC MOTOR BY THE NORTHERN ELECTRICAL MFG. CO., MADISON, WIS., U. S. A.

Direct-Current Motors.—These are sub-divided into two types, namely, "constant speed" and "variable speed." The constant speed, known as the "shunt" motor, runs, as its name indicates, at practically one speed, independent of the load, until it is severely overloaded, when it slows down, overheats, and sparks at the commutator. The variable-speed motor may be of two kinds, the "compound wound," which may increase or decrease speed as desired with a change in load; and the "series wound," in which the speed varies directly with the load and current. The series motor is the best known of the class, and is most useful for crane work, electric traction, and all service where powerful "torque" or turning moment is required in starting, stopping, and reversing a machine. All types of direct-current motors require a starting box or a controller, as the case may be. This is a resistance box of heavy wire, to choke down the current and prevent exeessive heating of the motor in starting until it reaches its normal speed, after which,—in shunt motors,—the current automatically adjusts itself to the power requirements.

Alternating-Current Motors.—The only type of alternating motor in practical use is called the "induction" motor. In this type brushes and commutators are entirely absent; in fact, the revolving armature has no electrical connection outside of itself. Current from the line is led to the stationary field magnets by three wires permanently connected thereto, making the machine electrically and mechanically of the simplest design. The induction motor is self-starting, simply by closing a switch, and it tends to run at a constant speed independent of the load, and can carry a heavy overload without



AN ELECTRICALLY DRIVEN BORING AND TURNING MILL BUILT BY THE POND MACHINE TOOL COMPANY, NEW YORK

injury, provided the heavy load is not continued until the motor becomes unduly heated. It is adapted to the same uses as the direct-current shunt motor, but it may also be applied to cranes or other uses requiring frequent starting and reversal, in which case a special controller is required.

EXAMPLES OF ELECTRIC SHOP POWER PLANTS

The Westinghouse Air-Brake Company.—This large plant consists of a compact group of buildings, and is devoted to the manufacture of light apparatus by means of tools, each of which requires but a small amount of power, the manufacturing being conducted by a symmetrical arrangement of group-driven tools from line shafting. The original power equipment consisted of a central boiler plant of 2000 horse-power, which furnished steam for heating and lighting, and to run air-pumps, and thirty Westinghouse compound steam-engines of 5 to 200 horse-power, placed in various departments and used to drive the line shafting. Although this system was well planned of its kind, the length of steam piping was necessarily considerable, and the losses from condensation were heavy. The great increase in business eventually overtaxed its capacity,—especially in the matter of boiler power,—and it was figured that the necessary relief for the boilers could be obtained through the superior economy of electric transmission. This was introduced under circumstances which make comparisons instructive.

Twenty-three of the separate engines

were replaced by three large condensing ones (Parsons steam turbines) of 400 horse-power each. These were placed in the engine-room adjoining the boilers, and each was direct-connected to a three-phase alternating generator running at 3600 revolutions. The power was thence distributed to fifty-six induction motors throughout the works. These motors have an aggregate nominal capacity of 1050 horse-power, of which two, aggregating 250 horse-power, are used for pumps, etc., in the power house, leaving 800 horse-power for shop power, as against 1300 nominal horse-power of the twenty-three steam-engines displaced. The manner of connecting the motors is for group-driving of tools from sections of line shafting, by belting to the motors placed on the ceiling timbers or other convenient places. The original shaft sections were about 400 feet long, driven by an engine belted to the middle of the length; for electric driving these sections are split up into four, with a motor for each. The motors are generally of 15 horse-power capacity, and drive the shaft sections at the most suitable speeds for the groups of tools connected. The shaft speeds were increased about 10 per cent. under the new arrangement, and range from 110 to 170 revolutions per minute. Thorough arrangements were made for comparative tests of results under the two systems of driving, this being accomplished by retaining temporarily all of the original steam-engine plant and converting the system from one method of driving to the other during the testing period. Details of the test results cannot be given in this place, but the general conclusions are interesting. These show a saving for electric driving during a 11½ hours' day run of 33 per cent. of fuel consumed, and about 40 per cent. in amount of water evaporated. This fuel saving represents the commercial economy of the new system, and results from several causes, namely, reduced shafting losses, superior economy of large condensing steam turbines over that of the small non-condensing steam-engines, elimination of condensation losses in steam piping, and better evaporation results from the boiler plant because of less forcing of the fires.

The Chicago & Great Western Railway.—The new shops of this company at Oelwein, Iowa, were planned for electric driving throughout, the system being of the 220-volt, direct-current type, with group-driven machine shop tools. The exhaust-steam method of heating is employed, using two fans, each driven by a 25 horse-power motor. An electrically-driven transfer table furnishes means for all transferring operations, large and small, the shops being specially arranged to be served from this one table, which travels at a speed of from 200 feet to 400 feet per minute. The electrical energy needed in winter, including power required to drive the heating fans, is:—

Average electrical horse-power, without lights	325
Maximum electrical horse-power, with lights	450
Night load	65
Nominal motor capacity, horse-power	450
Nominal general capacity, horse-power	525

The generating station is arranged with three equal units of 150 horse-power, an unusually liberal amount of power for the capacity of the motors connected,—a fact in part accounted for by the large percentage of power used to run the heating fans and for the lighting.

The General Electric Company's Shops.—The enormous plant of this company, at Schenectady, N. Y., is, as would be naturally supposed, equipped for electric driving, and represents their latest ideas. In this plant the methods for driving of both light and heavy machinery may be studied. Small and medium size tools are, in general, driven by the group plan, the short lines of shafting being run by variable speed motors mounted directly on the ends of the shafts, constituting a novel plan of driving without belting or gears, while large tools are driven by individual motors attached direct or by gearing. A noticeable feature is the use of portable or shifting tools for very large work. These tools are provided with geared motors, the tool being moved to the work, instead of the work

to the tool. This method is especially applicable for the machining of very heavy and bulky product, but may be used to advantage for special light tools in railway shops, as is pointed out elsewhere. The entire shops are served by electric power cranes. These are, in the larger sizes, provided with auxiliary hoists operating at fast lifting speeds for light work.

The system of wiring and the type of motors deserve special mention. The motors are of the direct-current, variable speed type, and the speed is regulated by a combination of two methods, as follows:—The distribution is on the "three-wire" system, the two outside wires having a voltage of 250 between them, while the middle wire carries a potential difference of 125 volts from the other two. The motors are wound for 250 volts, and are connected between the outside wires to run at a certain standard speed; for a lower speed the connections are switched to one outside and one intermediate wire, operating, therefore, at one-half voltage. From this lowest speed to the normal one at 250 volts a gradual speed rise is effected by weakening the magnet strength of the motor field; and, on the 250-volt connections, the motor is further speeded up by again weakening the field. It is seen that these valuable properties of wide speed range are obtained in a very simple manner. Examples of the speed variation possible in these motors are:—

4½	H.-P.	motor	runs at	400	to	800	revolut's	per	min.
7	"	"	"	250	"	500	"		"
12½	"	"	"	150	"	300	"		"
15	"	"	"	139	"	260	"		"

The Baldwin Locomotive Works.—These works, located at Philadelphia, illustrate one of the earliest, as well as probably the most extensive, examples of electric machine shop driving. It is not too much to say that their manufacturing methods to-day hinge largely upon changes made possible by the use of electric power, and that no other agency could be substituted wholly therefor except at incomparably greater expense in space, installation, and maintenance. In these immense works, situated in the heart of a great city, and employing 8000 men, the fullest utilisation of space and the utmost simplicity and rapidity of handling operations are essential, and many ingenious examples of the convenience and economy of electric driving are there to be seen. The electric plant is of the 250-volt, direct-current type, the generators being direct-connected and aggregating 1550 horse-power normal capacity. The motors are almost exclusively of the multipolar belted type, and number 320, having a total rated capacity of 3500 horse-power. Only about 5 per cent. of these motors are of the "series" type,—an unusual condition, and due to the fact that the cranes are equipped with shunt motors. About 950 horse-power at the power house switchboard is required on an average to run the entire power plant, and this figure is fairly constant throughout the day.

Electricity was first introduced in the erecting shop for driving two 100-ton travelling cranes, and an immediate saving of eighty men in the labouring force was thereby effected. The possibility of this result is seen when it is noted that a crane is capable of lifting an entire locomotive, or the parts of it, thus allowing the erection of a large number of locomotives to be carried on in a contracted space and without interference or delays connected with manual handling operations. Hand-drilling operations were also largely reduced in this department by substituting electric portable drills. In the wheel shop large economies resulted from electric driving. By remodelling the shop the overhead shafting was done away with, each lathe being equipped with a separate motor. The two main aisles formerly necessary for handling the work in and out of the machines were utilised for additional lathes, giving about one-third more machines in the same floor space, and the shop was served by an overhead travelling crane, instead of the hand jib-cranes in former use. The result was a reduction of the common labour force from forty men down to six, and a reduction of the time consumed in reload-

ing a lathe, from thirty to five minutes. The saving in power for this shop was also considerable, estimated at fully 50 per cent.

Similar results followed the introduction of electric driving in the frame shop, where the cutting out of overhead shafting and the use of travelling cranes enabled them to cut down the labouring force 60 per cent. In all the above cases the use of cranes was made possible only by the electric driving of the tools to be served by them. The motors are, in general, connected to large individual tools by belting from a self-contained countershaft and speed-changing drive mounted on a frame connected with the tool. Group driving from short-line shafts is employed for small tools. The cranes are of the single-motor type, having a shunt motor belted to a train of gearing and clutches. This type of crane is highly thought of in these works, and is considered superior to the three-motor type in its smoothness of action, ease and accuracy of handling, and reliability. It is, however, higher in first cost than the latter type. The cost of electric power at these works has been estimated at about $1200 per week, which sum includes cost of fuel, engineers and firemen, labour and material for repairs of power house, lines, and motors. It also includes interest and depreciation on first cost of plant. It is interesting to note that this entire amount is about 1.2 per cent. of the shop pay-roll.

AN ECONOMICAL STEAM POWER PLANT

AND WHAT IT TEACHES

By Geo. H. Barrus

ONE of the most economical steam power plants which it has been the good fortune of the writer to test is chosen as the subject of this article. In view of the high economical performance obtained, it is of interest to examine the features of the plant and ascertain the leading characteristics which produced the high results, and, having done this, it is proposed to take these results as a starting point and draw such conclusions as may be warranted on the possibilities of further economy, assuming improved conditions which are within the range of attainment.

The real economy of a power plant is measured by the total expenses of operation. The expenses to be met are not only those required for fuel, but there are fixed charges for interest, depreciation, etc., and expenses for wages of attendants, for oil, supplies, and repairs. It is not the purpose of this article, however, to go further than to consider the economy as relating solely to the single item of coal consumption, the only one of those mentioned which was carefully determined in the instance under consideration, and the one to which improvements of engineering design are the more commonly directed.

It is usually held that a plant, to be most economical, should be of considerable size, the larger the better. By "considerable size" is meant as large as single units can conveniently be made. We have stationary boilers which frequently run up into units of 500 boiler horse-power, or more, and we have engine units which are not uncommonly of 2500 horse-power capacity, with a tendency, in later practice, to run up into several thousand horse-power. The plant in question is one which with these comparisons would be considered rather small, the engine having a capacity of less than 1000 horse-power, and the boiler units being not over 150 boiler horse-power. Under these circumstances it might be said that the plant is not, in point of size, favourable to the highest economical results. This being the case, if an error is made in assuming that the results be held as a criterion of what might be expected in plants which are arranged in larger sized units, the error is on the safe side.

The plant was used as the motive power for a cotton mill, and consequently it was run at a reasonably steady load and under practically uniform conditions of operation. The running time was divided up into continuous periods of not over five and one-half hours, and the corresponding periods of the test were consequently of comparatively short duration.

THE BOILER PLANT

The boiler plant consisted of four vertical, tubular, firebox boilers, in which the diameter of the main shell was 67 inches; that of the firebox outside, 85 inches; and of the firebox inside, 78 inches. The crown sheet was 51 inches distant from the grate, and the distance between the tube sheets, and the length of the tubes, was 15 feet. In each shell there were 228

tubes, measuring $2\frac{1}{2}$ inches outside diameter, and having a collective opening of 20 per cent. of the grate surface. The diameter of the grate was 78 inches, making an area of grate surface of 33.2 square feet, half of which was composed of metal and half air opening.

The water-line was carried at such a height that about 4 feet 9 inches of the upper ends of the tubes were exposed to the escaping gases, and served as steam heating surface. The water heating surface in each boiler had an area of 1489 square feet, or 44.8 times the area of the grate surface; and the steam heating surface, 665 square feet, or twenty times the area of the grate surface, making a total of 2154 square feet of heating surface for each boiler. The superheating surface was of sufficient capacity to heat the steam 12.4 degrees above the normal temperature when the boilers were running at their usual capacity. The exterior surfaces of the boiler shells were protected from radiation by means of magnesia covering.

From the boilers the products of combustion and escaping gases passed through a rectangular flue into a brick chamber containing a feed-water heater, or economiser, and thence to the brick chimney upon which dependence was placed for draught, the latter being controlled by an automatic steam pressure regulator acting upon a damper between the economiser and the chimney. The economiser contained vertical cast-iron pipes, provided with scrapers, which presented a total area of outside heating surface amounting to 2204 square feet, or slightly more than the total heating surface, both water and steam, presented by a single boiler. Two boilers were sufficient to furnish the steam required for the engine, and this was the number in use when the test was made. One of the remaining boilers was idle, and the other, running at a comparatively slow rate, was employed in furnishing steam for miscellaneous heating purposes about the mill.

Running in this way, that is, two boilers on the engine, one on the mill, and one idle, the escaping gases left the boilers and entered the economiser at a temperature of 520 degrees, and they left the economiser and entered the chimney at 322 degees. At the same time, the feed-water entered the economiser at 101 degrees, and left it and entered the boilers at 209 degrees. The loss of temperature of the gases in passing through was 198 degrees, and the corresponding gain in the temperature of the water was 108 degrees

The chimney was 150 feet high, with an interior flue 5 feet in diameter. Much less than the full draught of the chimney was required, the automatic damper cutting it down so that the average force of the draught in the main flue between the economiser and the boilers was only 0.16 of an inch water pressure. This was sufficient to burn the quantity of coal required, the rate of combustion being 11.7 pounds per square foot of grate per hour. The amount of boiler horse-power developed was 248.6, which is rather less than the rated capacity of the two boilers.

It is noticeable here that the coal was burned with a comparatively small force of draught. This is one of the features of the vertical type of boiler, as the natural upward tendency of the products of combustion through the vertical tubes produces a draught of its own. The draught of the chimney under the reduced temperature of the gases leaving the economiser was about 0.6 of an inch. The relation between this force and that actually required at the boiler, which, as will be seen, is nearly 4 to 1, reveals this feature of the action of the vertical type in the clearest manner. The character of the combustion produced under these conditions is evidenced by the results of the gas analyses, which showed 13.1 per cent. carbon dioxide, 5.7 per cent. oxygen, and 0.6 per cent. carbon monoxide, all referred to volume. With this composition, the amount of air supplied per pound of combustible figures out 15.5 pounds.

The feed-water for the boilers was supplied by a plunger pump, operated by a belt from the main source of power. This fed the water through the economiser into the two boilers supplying

the engine, while the auxiliary boiler was fed from another source. The water supplied to the pump was drawn from the hot well of the condenser after receiving the hot water from the engine jackets.

As a result of the evaporative work done by the two boilers for a period of 14.27 hours, 11,080 pounds of dry Cumberland coal were burned, and 115,496 pounds of water were evaporated, the steam pressure being 153.4 pounds; the temperature of the water entering the boilers, 209 degrees; and the steam superheated, 12.4 degrees. With these data, the weight of water evaporated per pound of dry coal was 10.424 pounds, and this is equivalent to 12.03 pounds evaporated from and at 212 degrees per pound of combustible, the percentage of ash in the coal being 8.5 per cent. The total heat of combustion of the coal by calorimeter test was 14,869 B. T. U. per pound of combustible, and the efficiency of the boiler on this basis, that is, the percentage of the total heat utilised in evaporation, is 78.2 per cent.

The steam, on leaving the boilers, passed through a 9-inch main pipe, which extends a length of 75 feet from the throttle valve of the engine. It contained five short, right-angle turns, and a steam separator near the throttle valve. The steam pipe diagrams taken from this pipe near the cylinders showed a fluctuation of pressure at this point amounting to five pounds, and, so far as fluctuation was concerned, there was no appreciable difference produced by the resistance interposed by the separator.

THE ENGINE

The engine consisted of two horizontal cylinders arranged on the cross-compound system. The high-pressure cylinder was jacketed both on the heads and around the barrel. The low-pressure cylinder was jacketed on the heads, but not on the barrel. The diameter of the high-pressure cylinder was 18 inches; that of the low-pressure cylinder, 48 inches; and the stroke of both, 4 feet. The steam exhausted from the high-pressure cylinder passed through an 8-inch pipe containing a horizontal tubular reheater, which had 187 square feet of heating surface. The jacketed spaces of the cylinders and the tubes of the reheater were supplied with steam of full boiler pressure, and the resulting water condensed was pumped into the boilers.

It was found that, under the test conditions, the amount of water thus condensed averaged 9.5 per cent. of the total weight of steam supplied to the cylinders. The shell of the reheater was drained by a trap, and the water was thrown away. When the engine was running at its ordinary capacity 184 pounds of water were discharged per hour at this point. At the same time, there is sufficient tube surface in the reheater acted upon by boiler steam to superheat the steam passing from the reheater to the low-pressure cylinder an average of 32 degrees. The clearance of the high-pressure cylinder was 2 per cent., and that of the low-pressure cylinder 2¾ per cent. The ratio of volumes of the cylinders was unusually large, being 7.3 to 1. The valves of each cylinder consisted of one steam and one exhaust valve for each end, and these were gridiron slides. The steam valves were rendered automatic by the action of the cut-off mechanism attached to a ball governor. The cut-off of the low-pressure cylinder was adjustable by hand, in addition to being connected with the governor. The valves were not absolutely tight, especially one of the exhaust valves of the low-pressure cylinder, and the high-pressure piston leaked to some extent. The engine, on the whole, was found to be in as good condition as the average engine, but not in the best condition, as sometimes occurs.

The condenser was of the siphon type, depending on a barometric tube for the maintenance of the vacuum. It was supplied with water by gravity, and neither pump nor power was required to handle either the injection water or the overflow water.

During the progress of the test, which continued for three periods, aggregating

14.27 hours, the engine ran at a speed of eighty revolutions per minute, and developed an average of 660.1 I. H. P. Of this, 299.8 horse-power was developed by the high-pressure cylinder, and 360.3 H. P. by the low-pressure cylinder, the mean effective pressure in the cylinders being, respectively, 62 pounds and 10.2 pounds. The pressure in the steam pipe was 150.2 pounds, the pressure in the receiver 14.9 pounds, and the vacuum in the condenser 26.6 inches. The initial pressure above atmosphere in the high-pressure cylinder was 143 pounds, and in the low-pressure cylinder 14.5 pounds. The back-pressure in the high-pressure cylinder was 16.5 pounds above the atmosphere, and in the low-pressure cylinder 13 pounds below the atmosphere. The cut-off in the high-pressure cylinder occurred at 28.5 per cent. of the stroke, and in the low-pressure cylinder at 17.6 per cent. of the stroke. The steam accounted for by the diagram at cut-off in the high-pressure cylinder was 9.21 pounds, and in the low-pressure cylinder 7.96 pounds, and these are, respectively, 75 per cent. and 65 per cent. of the actual steam consumption, the total amount used by the engine being 12.27 pounds per I. H. P. per hour.

THE GENERAL RESULT

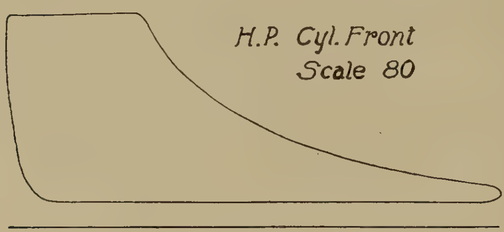
For the entire time of the periods covered by the test, aggregating 14.27 hours, the weight of dry Cumberland coal consumed was 11,080 pounds, or 776.5 pounds per hour. The average indicated horse-power developed by the engine was 660.1; consequently, the weight of dry coal consumed per I. H. P. per hour was 1.18 pounds. This result is an excellent one, when compared with the work of many plants which are generally considered to be doing good work if they develop a horse-power on 1.5 pounds of coal per I. H. P. per hour.

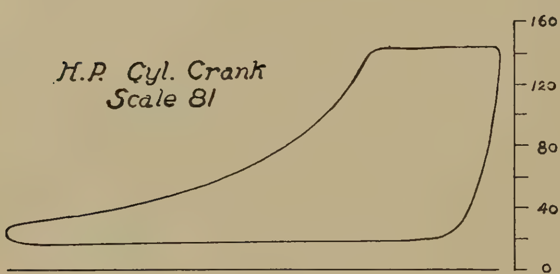
Having given the particulars in regard to the design of the plant, and the results of the test, we may now analyse the matter closely and see what were the main features which contributed to the high performance. Starting with the boilers, a fairly high efficiency was realised in the evaporative work. With a hand-fired furnace it is seldom that an efficiency much higher than 78 per cent., which was obtained in this case, can be realised; and this result points not only to an efficient design and proportioning of the boiler and heating surfaces, but also to efficient work in the firing of the coal and the operation of the boiler. Coupled with this, was a considerable gain produced by saving the heat of the waste gases by the economiser, for the heating of the water by this means to the extent of 108 degrees represents the utilisation of about 10 per cent. of the total amount of heat used in the evaporation.

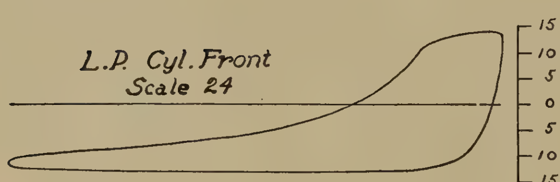
If we take into account the heat thus utilised, and compare the total amount of heat absorbed by the boiler and economiser with the heat of combustion of the coal, the efficiency of the combined generating apparatus runs up to 86.5 per cent., leaving only 13.5 per cent for losses due to radiation, incomplete combustion, and that produced by the heat of the gases leaving the economiser and entering the chimney, which is about as low as these losses could be expected to aggregate. The coal used was not the best kind obtainable, but Cumberland coal belongs to the class of American semi-bituminous coals which possess the highest calorific qualities, and from which the best results in practical work are usually obtained. To start with, then, the high performance of this plant is due to the use of good coal in a well-proportioned and skilfully operated boiler, with all the waste due to combustion prevented, so far as it is practicable to do so in hand-fired furnaces.

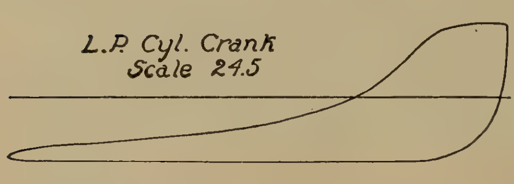
Passing to the engine, a number of noticeable features appear, which evidently contributed a share to the final result. Perhaps the most noticeable characteristic of this engine is the high ratio of volumes existing between the two cylinders. Ordinary practice in the design of compound work establishes a ratio of between 4 and 5 to 1. The ratio here goes about 50 per cent. beyond the custom. The fact that high

economy in steam consumption was obtained with this ratio of volumes, is not of itself more than an indication that the large ratio was the principal cause. To prove the matter it would be necessary to compare two engines having precisely the same features of design and construction, in which the only difference between them is the single difference of volumes. It seems to be a reasonable









conclusion, however, that an increase in the ratio of volume should tend to improve the economy, provided the pressure is sufficient; and it seems to be generally agreed that, as the pressure increases, the ratio of volume of the two cylinders should be in some measure increased also. The conclusion seems to be justified that, in view of the fairly high pressure which was carried, the high ratio of the cylinders was advantageous, and that this high pressure, under the circumstances, contributed much to the high economy produced.

No less noticeable is the appearance of the indicator diagrams, and the excellent distribution of steam which they reveal in the working of the valve mechanism. Copies of sample diagrams, on a reduced scale, are given on this page. There is a marked absence of wire-drawing of the steam during admission to the high-pressure cylinder. There were no undue losses of area produced by faulty valve action, or choked ports and passages. Other things being the same, these characteristics can have no other influence than to improve the economy of steam consumption. It will be noticed that the cut-off of the low-pressure cylinder on these diagrams is considerably shorter than that of the high-pressure cylinder. This is one of the effects due to the large relative volume of the low-pressure cylinder.

It is interesting to note that the engine was found slightly more economical when running under these conditions than it was when the cut-off of the two cylinders was more nearly equal. When the cut-off in the low-pressure cylinder was 32 per cent., and that in the high-pressure cylinder 28 per cent., the feed-water consumed per I. H. P. per hour for a run of five hours was 12.29 pounds. When the cut-off in the low-pressure cylinder was reduced to 24 per cent. the consumption decreased to 12.03 pounds, and when the cut-off in the low-pressure cylinder was reduced to 17 per cent., corresponding to the work of the test, the consumption fell still further, to 11.89 pounds.

Another feature in the work of this engine is the use of slightly superheated steam, jacketed cylinders, and a reheater. These undoubtedly produce some advantage. This is shown by the results of experiments made by the writer on other engines with and without superheating, and with and without the use of steam in jackets and reheater. These points are not capable of being determined exactly without trial on the particular engine in question, but it

seems to the writer that their combined advantage produced an economy which can safely be placed between 3 and 5 per cent. The shutting-off of the boiler steam from the jackets and reheater in one case of an engine of this kind, which was supplied with ordinary steam, increased the consumption of steam 2 per cent.

Although the engine appears to be highly efficient, when the actual weight of steam consumed alone is considered, it does not appear so efficient when the work of the steam in the cylinders is analysed, and a comparison is made between the actual consumption and that revealed by the diagram The steam accounted for by the indicator at cut-off of the high-pressure cylinder, as already stated, was 75 per cent of the actual amount of steam consumed. For an engine which is jacketed and supplied with slightly superheated steam this proportion is rather low.

In a perfectly tight engine, which was supplied with ordinary dry steam and had no benefit from steam jackets, the writer has found 80 per cent of the steam accounted for in the high-pressure cylinder. The difference between 75 per cent. and 80 per cent. in an engine of this class represents three-quarters of a pound steam consumption per I. H. P. per hour. This furnishes strong ground for the conclusion that if the engine under consideration had been perfectly tight, and in all respects in the best condition, the performance would have been considerably improved.

A still further feature in the design of this plant, which contributed not a little to the high economy obtained, was the absence of steam-driven auxiliaries for operating the condenser and feed-pumps The whole steam used by the plant was consumed either in the cylinders of the engine, or condensed in the jackets, and there were no losses of steam of any kind, except the slight ones which invariably exist, due to leakage of joints, stuffing-boxes and piping.

CONCLUSIONS FROM THE TESTS

From a careful reading of the facts regarding these tests, it will appear that a steam plant which is not in the best condition, and which is not operated in all respects in such a manner as to secure the best obtainable results, can readily produce a horse-power on a consumption of 1.18 pounds of dry Cumberland coal per hour, and it will suggest means by which the economy can be improved. It is not too much to expect that by these means the consumption of coal in a plant of the kind described could be reduced to not more than one pound per hour per I. H. P.

The first step suggested is to employ the highest grade of semi-bituminous coal. The coal used on the test was inferior, as compared with coal showing the highest calorific value. The best grades run as high as 15,000 B. T. U. per pound of dry coal, as against the 13.970, which applies to the coal tested. Without going to extremes, if we use 14,750 as a practicable figure, and assume that coal of this kind was used in place of the coal employed on the test, we reduce the coal consumption 5 per cent., or 0.06 pounds per I. H. P. per hour.

The second step for improving the performance is, naturally, the correction of the engine leakage which occurred, and other losses, which were the cause of the low percentage of steam accounted for by the diagrams, as referred to, amounting to three-quarters of a pound of steam per I. H. P. per hour, or 6 per cent. of the total consumption. If the defects producing this loss were remedied, the coal consumption would be reduced to the further extent of 0.07 pounds per I. H. P. per hour.

The third step for improvement that suggests itself lies in the direction of employing a higher boiler pressure. If we increase this to 200 pounds, and carry the expansion line of the high-pressure diagram up to the new steam line without changing the remaining portion of the diagram, it will be found that about ten pounds mean effective pressure can be added to the high-pressure cylinder without sensibly changing the conditions of operation of the steam in this cylinder. This will add about 8 per cent. to the power de-

veloped by the engine, and improve the economy, after allowing for the increased cylinder condensation, about 5 per cent., or 0.05 pounds of coal per I. H. P. per hour.

Adding together these three items, we have a saving of 0.18 of a pound per I. H. P. per hour which is practicable, and this brings the consumption of coal down to one pound per I. H. P. per hour. We might go further and point out wherein still greater economy could be secured by the use of mechanical stokers in place of hand-firing. This is enough, however, to show that with the increase of boiler pressure, which seems to be the tendency of modern steam engineering, the time will soon come when the unit of one pound weight of coal per hour will be considered as a standard of consumption in the development of an indicated horse-power.

AMERICAN COMPETITION IN THE WORLD'S ENGINEERING TRADES

FROM AMERICAN POINTS OF VIEW

AMERICAN competition is just now the one topic of commanding importance in the world's engineering trades and an immense amount of speculative reasoning has accordingly been going on as to the causes of the threatened American industrial supremacy in the markets of the universe.

Superior manufacturing methods, native American enterprise, better products, better equipment, better workmen,—one and all have been held to explain, rightly or wrongly, why America has latterly forged ahead with such amazing rapidity, but none of them has afforded a satisfactory degree of consolation to British and Continental manufacturers for the circumstance that their trade has not kept pace with that of the vigorous young republic on the other side of the Atlantic. Still, the principal factors in that trade expansion, considered from the points of view of the men who have helped to bring it about, ought to prove excellent subjects for study for some time to come; hence the opinions in the following pages of a number of prominent American works managers and engineers, obtained specially for publication here.—THE EDITOR.

To understand aright the reasons for the exchange that is taking place in the possession of trade supremacy from Great Britain to the United States, it will be necessary to review the history of the industrial development of these two countries during the immediate past, and note the differences in the commercial achievements of each, respectively.

Looking backward for a place at which to begin, we find that, with the perfection of the Bessemer process of making steel, at the beginning of the last third of the nineteenth century, there was born an era of railway building which spread across two continents, giving an impetus to industrial enterprise and commercial development unprecedented in the annals of history. Up to this time the people of the United States were both agricultural and maritime in their pursuits. Immigration was spreading itself largely throughout the Middle West, and commercial demands were not yet of such a character as to inspire to exertion the inventive genius of the country. Transportation

acilities were too poor to encourage the installment of factories far distant from the coast, and what little manufacturing was being done was by no means sufficient to meet the requirements of the rapidly increasing population. Thus, two-thirds of the last century had passed without any special impress having been made upon the markets of the world by the United States as a manufacturing nation.

On the other hand, Great Britain had, at that time, by slow development, grown to be the great manufacturing centre of the world. Raw materials were brought to her from all parts of the world to be converted into finished product, which, in turn, was carried in her own vessels to her colonies and foreign markets.

The growth of Great Britain's manufacturing interests had been slow, and, to a large extent, due to the guilds, which, a natural heritance of feudal times, had formed after the Middle Ages. As long as the trades were considered arts, the secrets of which were possessed by the few and handed down through families, the artisans were all-powerful, and determined the success or failure of many an individual enterprise. Gradually, however, as the sciences became exact, the latter took their place in the industrial arts, relegating the skilled artisan to the grade of labourer, and substituting machinery in his place. To check this attack of the aroused intelligence of the age, labour massed itself under the leadership of those who were the best politicians, and by strikes and similar repressive measures endeavoured to push back the tide which, as a little foresight would have shown, would eventually overwhelm it.

Thus an ever-widening market, supplied by a limited producing capacity, gave little opportunity for competition, and, at the same time, afforded the best possible conditions for aggressive and intolerant labour dictation. Such dictation is invariably in the interest of the incompetent. Those who are capable can always command the highest wages. In times of labour disturbances, therefore, the best men seek localities where their interests will not be interfered with, and Great Britain lost her best mechanics at a time when she could least afford such a loss.

Great Britain and the United States were in the relative conditions just described when the Bessemer process of making steel was developed, and steel rails were supplied to Europe and America at prices which placed railway building within the reach of available capital. The impetus given to industrial and commercial activity by the railways, which spread out in every direction, attracted foreign capital to the United States, where, fostered by a protective tariff, returns were sure, and at a high rate of interest.

Encouraged by the prospect of immediate and large benefits, capital flowed into channels opened by the inventive genius of the age, which, coming from the lately established technical schools, was then beginning to encroach upon the domain of the older empiricists. The ceaseless flood of immigration to the United States brought with it skilled mechanics of all nationalities and in all branches of trade, who left Europe especially attracted by the higher wages which everywhere obtained. The enormous demand for improved products which opened on every hand, caused, during the first wave of financial buoyancy, the establishment of a multiplicity of factories in every industry, each striving for a share of the profits which must have had the appearance of being inexhaustible. The reaction which these conditions necessarily precipitated forced these many factories into severe and close competition, and this, in turn, brought about what has been denominated as "American methods." This name covers the specialisation of men for certain classes of work by which means duplicate pieces can be manufactured, not only accurately alike, but at low cost. The extremely low margin of profits which resulted from competition finally caused a combination of the representative factories in each industry, and these, in turn, had to meet such competition as

arose against them not only in the United States, but from other countries.

Thus gradually there have been developed methods of reducing cost of product, and of producing large quantities of work of high grade. The great producing capacity of some of these combinations has compelled them to seek for wider markets than America afforded in order to keep their plants in full and economic operation, and thus secure adequate interest on the investment.

The labour troubles which during the last few years have paralysed industry in Great Britain, granted a favourable opportunity to enter that market, which American enterprise, now ready for foreign conquest, has not been slow to seize.

At the same time, famines in India and Russia, wars in South Africa and China, and the partial failure of crops throughout Europe, coupled with most bountiful harvests in America, have turned the flow of gold towards the United States and thus supplied the means for commercial aggression.

The attacking power of the great industrial combinations, with thousands of employees and enormous capital, directed by the master minds of a few men, would, even under ordinary circumstances, be great; but, under the favourable conditions existing in Great Britain, it has been irresistible.

Ground has thus been gained by the United States which can with difficulty be retaken by Great Britain. Only conditions which the United States themselves may invite will bring about retreat. Yet some of these are even now beginning to threaten. Reckless speculation, through over-confidence in a continuance of prosperity beyond the time for a natural reaction, will lead to severe trade depression. The recent labour troubles also in the Middle West cannot be viewed without great apprehension. Knowing the effect of similar disturbances in Great Britain, unless like occurrences are summarily checked, it is a foregone conclusion that American trade ascendency, recently acquired from Great Britain, will be soon restored to its recent possessor.

It behooves, therefore, American social scientists to devise means to bring labour and capital to a more thorough understanding of their mutual interests. Not only should the principles of economics be taught in the universities, but in the high schools as well. Manufacturer and employee must be brought to understand that their interests are common. The employer must be more altruistic than in the past. The employee must be more amenable to reason.

Labour organisations, when governed by able minds, are productive of great good, not only to their members, but to the industries which they represent. When led by demagogues, however, whose sole interest is their own support, disaster is sure to follow, which may not end until it has carried down the fortunes of a nation.

H. F. J. PORTER, *The Bethlehem Steel Company, South Bethlehem, Pa.*

THE recent phenomenal growth of American engineering products has excited not only a great deal of attention in Great Britain and Continental Europe, but no little surprise, as well, among Americans themselves, and the daily press has given free rein to its imagination in describing the new position of the United States as the chief exporting nation of the world. If we could consider these articles merely as after-breakfast reading, it would not be worth our while to give them any further attention; but they may work an injury to us if they lead us into the pleasant delusion that this recent expansion of our engineering exports is the result of nothing else but the recognition by European nations of our great superiority, and that our position at the head will continue as a matter of course.

It must be borne in mind that Europe has bought largely of our engineering

products during the past few years chiefly because the home demands could not be filled by their own industrial establishments. It has happened also, for our good fortune, that what we had to offer to them was much better than the machinery they have been in the habit of using in the past. There was, therefore, an added inducement to their purchasing more freely, not only to satisfy their actual requirements, but also to increase their own productive capacity, when it had been discovered that American machinery was more efficient than what they had been using.

During the past ten years the engineering works of Europe have been obtaining very high prices for their products. The demand seemed to be without end, and in some countries there had been a general scramble to see who could gain the most profit by increasing the productive capacity of his works as quickly as possible. Naturally, under these circumstances the engineering establishments made work for one another, and much over-production and over-expansion has resulted as a necessary consequence.

Many Americans have wondered how it was possible for a works in Connecticut to send men and material to erect a foundry in Berlin, not only more quickly, but also at a less cost than the sum for which the work could be done by German firms, and it also appears singular that the same German company for whom the foundry was built should have bought every machine of its entire equipment in the United States. While this tribute is very flattering to American pride, it will remain the solitary instance of its kind unless American manufacturers are willing to learn the lesson which it teaches, namely, that American mechanical products are the best in the world to-day, and that they can command a market with an intelligent buyer, provided the conditions are such that the purchaser can afford to pay for the goods. In the case here considered the purchasing company was one of the most progressive in the world and had unlimited capital. The American manufacturer would like to see this instance repeated not only once, but a great number of times; but he must bear in mind that this desirable result can be reached only by the gentle art of persuasion,—by making it advantageous to the foreign buyer to take American goods.

There is nothing to be gained by dwelling upon the undisputable fact that, in mechanical engineering, we are in advance of the world. Let us rather busy ourselves with the study of how to preserve this position and turn it to the best advantage. At present we must meet the fact that there are plenty of excellent, capable engineers in Great Britain and on the Continent who are studying American methods and mastering them. All the best types of American machines are copied, more or less, in Europe at present, and, granting that the originals are better than the copies, we are driven to admit, if we want to be fair, that the difference between them is no longer extreme. A very intelligent American engineer, who is thoroughly posted regarding the respective merits of American and German machinery, told the writer that the American machine could not command much more than 10 per cent. in price over and above the German copy. What would be the effect upon the American export engineering trade if the transatlantic countries were to unite and put a duty on American engineering products equal to one-half of the American tariff?

The great majority of American citizens have been brought up with the very narrow idea of America for the Americans, and their horizon was easily found,—it ended with the boundaries of the United States. The rapid and enormous growth of American exports has shown conclusively that America's abundant resources are too great to be restricted to a home trade only, and that America will be forced to seek and cultivate commercial relations with other nations. Any other policy will be followed by great over-production at home, accompanied by periods of great over-supply every few years, with resulting panics and commercial disaster.

Commerce is simply exchange, and there can be no profitable commerce for any length of time with a nation which is willing only to sell. Circumstances may, and frequently will, compel other nations to satisfy their immediate wants by purchasing from us; but they will be forced to discontinue these purchases at the earliest possible moment, if they have to pay for what they buy in money, for it is quite clear that any other course would plunge them into ruin. In order to buy, a merchant must also be able to sell his goods, otherwise he cannot pay his bills, and goes into bankruptcy. A nation is merely an aggregate of individuals. It seems to the writer that there is no great difficulty in this problem of how to keep our present advantage, and that a people of our intelligence ought to be able to find the way easily enough. At the same time, it must be admitted that even Americans are apt to think in grooves, and that nothing short of another period of over-supply and great financial distress will lead many of them to ask themselves how they can dispose of their surplus product.

HENRY BINSSE, *The Newark Machine Tool Works, Newark, New Jersey.*

SOME of the reasons for the rapid advance of America to a foremost place in the industrial world are, on examination, seen to be the same as those which gave Great Britain the primacy for a long time. These include great supplies of mineral resources, and a special development of certain lines of manufacture which seemed specially adapted to the country. Even now, in nearly all the lines of shipbuilding, Great Britain retains her supremacy, and very largely because certain firms have limited themselves to special classes of vessels. Note that Yarrow and Thornycroft build only torpedo craft and shallow-draught vessels; other firms build only cargo boats, and others, still, only yachts. The firm of which the late Thomas Mudd was managing director stuck to machinery for cargo vessels, and even, to a great extent, to one size. Competition with work so specialised was simply out of the question unless similar specialisation was adopted by others.

The primary cause of America's progress is, undoubtedly, the wonderful endowment of the country in situation, climate, natural resources, and people. Such a combination, in due time, would bring about the same result anywhere, even under a poor form of government, and we Americans believe that our form is the best. Indeed, this is one great factor in America's supremacy, for, combined with the country's youth as a nation, it has made it easier to develop new industries because of few vested interests and freedom from vexatious restrictions.

The absence of rigid class distinctions, and, until recently, of large inherited fortunes, has opened the way for talent and industry to attain the highest positions in the industrial world, however humble and moderate their beginning. The vast majority of America's leading men in manufacture made their own fortunes, and a great many began life very poor. No other country can show such a record. The fact, too, of fortunes having been so built up, gives America a race of capitalists of unequalled courage and experience, so that they are more ready to undertake new lines of work and vast enterprises than men who have inherited long-established businesses as well as fortunes.

The youth of a country is sometimes a great advantage. Until the advent of the trolley car America had, speaking broadly, no decent system of urban rapid transit. The cab system was, as a rule, organised robbery, and the average town had either the leisurely horse car or nothing. Even the small towns in Europe had a cheap and efficient cab system. Note the result! As soon as the electric car was reasonably successful it was introduced everywhere in America, because there was no other half decent system to be displaced. In a few large cities efficient cable roads

held on for a time, but these have now nearly all been changed to electric traction, and the experience with electric traction has had a great influence in the growth and development of electric works in America.

Again, the vast extent of the country and the development of means of communication, including both common roads and railways, made an immense demand for bridges. The relatively sparse population compelled their construction cheaply. This, in turn, following the national tendency to standardisation and uniformity, caused the organisation of bridge construction as *manufacture* rather than building; and, like Mr. Mudd's engines, American bridges can beat the product of any works not organised on the same lines, both in price and time of delivery.

There can be no question, too, that the workman is a vital factor in the problem. Americans have long boasted of the ingenuity and skill of the native-born workman, and it is probable that the greater part of the foreign-born workmen in the United States are the cream of the countries from which they come. The very fact of their leaving home shows that they are the most enterprising. There is good reason for believing also that they are not only more skillful and diligent, but more docile and tractable.

In America there has never been such a general stand for claims like the "one man, one machine," as in Great Britain. Indeed, America's development in automatic and labour-saving machinery would have been almost impossible if her workmen had generally taken such a stand. On the contrary, much of the development along these lines has been due to the men themselves. While there have been many strikes in America, and some on very frivolous pretexts, they have not, as a rule, had such utterly senseless features as characterised the great strike of 1897 in the British engineering trades. Had the employers yielded at that time, not only would they have been ruined, but the men as well. Even as it is, the strike has had a most unfavourable effect.

It appears, also, that the American workmen are much better time-keepers and far less given to dissipation than those in Great Britain. One of the best firms of British shipbuilders, who have had no trouble with their men for years, recently stated that there is a loss of time, amounting to nearly 20 per cent., due largely to drunkenness. If anything approaching these figures is true generally, there can be no surprise that firms open to competition from well-managed American works should have a hard time.

It must not be forgotten that America has had a wonderful stimulus to development in manufacture from the immense immigration. With such a market at home, an enterprising race of people was bound to improve the opportunity. Then, when well developed, the reaching-out for foreign markets became inevitable.

Many items have, of necessity, been ignored in this brief sketch. Some may think that important ones have been overlooked. Probably the whole situation could be summed up by saying that the Americans have fulfilled Shakespeare's well-known saying:—

> "There is a tide in the affairs of men,
> Which, taken at the flood, leads on to fortune."

WALTER M. MCFARLAND, *Pittsburgh, Pa.*

DURING the past fifty years Great Britain has easily led all other countries, excepting the United States, in what are known as the engineering trades, and still more has she excelled all others in the export of products of this class. But as the twentieth century opens, Great Britain's supremacy in these respects is being wrested from her by America. In my opinion, the chief causes for this are as follows:—

American labour has long been conceded to have higher efficiency than any other Heretofore it has been

handicapped by a high cost of living, which, in turn, operated to keep the wage rate on a higher level than would otherwise be necessary. The great cheapening in the cost of production of every kind which has been accomplished in the United States during the last generation, but, above all, since the panic of 1893, has tended to a somewhat lower average rate of wage, without any curtailment of purchasing power. Simultaneously the course of wages in Great Britain has been upwards. These conditions have tended steadily towards an equalisation of wages in the two countries chiefly identified with the development and progress of the engineering trades. If due allowance be made for the fact that the working hours in the United States are somewhat longer than in Great Britain (which implies correspondingly greater output of machinery), and that British manufacturers are far more heavily handicapped than those in America by unreasonable exactions and interference from organised labour, it is probable that the wages rates of the two countries, measured by their productive return, are already fully equalised, while the admittedly higher intelligence and skill of the American workman is rapidly operating to give the United States cheaper raw materials in nearly every industry.

The American manufacturer, with equal wages, with equal or better machinery, and with his greater courage in initiating new departures, and his admittedly greater "push," has conquered, and now holds, the position of pre-eminence formerly, and for at least two generations, enjoyed by his British competitor.

If the facts are as herein assumed, they are a sufficient explanation of the changed condition of American products in the markets of the world. Industrial supremacy belongs to that country which enjoys the cheapest materials, the most improved machinery, and the most efficient labour. Heretofore these advantages have been Great Britain's; to-day they are America's.

HENRY R. TOWNE, *The Yale & Towne Manufacturing Co., Stamford, Conn.*

THE causes which lie at the foundation of the rapid growth of exports of American manufactures I would summarise as follows:—

1. Cheaper and More Abundant Raw Materials. These are notably coal, iron, steel, copper, and timber. Coal is at the foundation of all modern industry. Cheap iron and steel for structural purposes follow next. In this age of electrical development it means much also that America supplies the world with copper. As the uses of steel grow, the relative importance of lumber diminishes. Yet the vast timber supply of the United States is of untold benefit in the building of industries whose products seek the markets of the world.

2. Superior Labour. American labour is under better control, is more intelligent and ingenious, and works to better purposes than the labour of Great Britain and the Continent. Each one of the competing industrial nations is handicapped in some form or other by its workmen. In Great Britain trades unionism devotes its energies to reducing the per diem output of each man to a minimum, in order that employment may go further and wages be higher. Sir Hiram S. Maxim, in a late address, gave an instance of a small gun attachment which the labour union committee classified as a day and a quarter's work. He invented a machine to make it, but the men would produce the piece only in a day and a quarter, even with the machine. He then hired a German workman, who easily produced thirteen pieces in a day.

A further point is that the British workman celebrates many holidays, compelling the closing of factories for days at a time during, perhaps, busy periods. In Germany hours are longer nominally, but the entire cessation of work during certain hours of the day for beer and lunches cuts down the units

of product. Besides, the German workman, while patient and industrious on familiar lines, is less facile when it comes to new and unaccustomed forms. I have seen in German, Swiss, and Alsatian machine shops finer finished machinery than I have ever noticed in America, but under their system it could not be produced cheaply.

3. More Progressive Management. American manufacturers not only get more out of their machines and men, but they are more progressive and up-to-date on the commercial side of the business. They have no hereditary prejudices or race conservatism to overcome; if there is a better way, they want to know it and adopt it. No one who has not mingled with British manufacturers, for instance, can appreciate the extent of this conservatism, which is satisfied with what is old, and solid, and British, and views with skeptical indifference newer and better ways. Vacations and sports also cut a large figure with masters and men. In the earnest discussions now going on in Great Britain over alleged American superiority, those who admit it frankly raise the question whether it is not better to work and worry less, and live longer, like the British, than to push and accomplish more, and break down earlier, like the Americans. This view, while philosophical, seems hopeless. It is equivalent to saying that it is better to be whipped in a military or industrial battle than to over-exert one's self and lose too many comforts and pleasures.

The superiority of American management takes many forms, not easy to always define. Indeed, America's industrial rivals who have studied American shops and methods often deny that the newer ways are better. But what goes under the head of American shrewdness and energy is, nevertheless, a very large factor in the growth of American export trade.

4. Better Plant. Here there is no room for argument. German, Belgian, Swedish, British, Italian, and Russian engineers have been coming to the United States for two years past, in a continuous procession, and all intent on inspection of the great industrial plants of the country. The testimony of these expert pilgrims is all one way. The Americans, in the past decade, have gone beyond any rivals in any age in the construction of works in which the latest science and most approved methods find expression. The goal toward which all successful manufacturers work is the maximum of units of product at the minimum of cost per unit. This is attained, in part, by large plants and improved machinery, and, in part, by specialisation,—concentration upon a single specialty.

For example, in a great shop at Mulhouse, in Alsace, employing five thousand men, I saw waterworks and blowing engines, locomotives and other heavy machinery, along with cotton spinning machinery and the lightest articles made in iron. The same range of manufacturing would, in the United States, call for half a dozen separate plants, each concentrating effort on a single product, and selling it at figures for which the Alsatian works could not dream of making it. In Great Britain to use another illustration, an agricultural implement works makes road engines, threshers, mowers and reapers, cultivators, and a variety of small farm tools. But when they put any one of their machines into the field, they meet a Chicago made article which is laid down on the spot at a less price than that for which the British firm can hope to simply produce it. The Chicago manufacturer builds a vast works to make nothing but mowers and binders. One concern employs thousands of men on threshing machines and road engines to haul them, while still other large factories make the cultivators, drills, etc. Machines turned out by tens of thousands, instead of thousands, can be made in greater perfection and at materially lower cost, even if all other factors are uniform. But if cheaper raw materials, more efficient labour, better management, and more up-to-date works be added, the transatlantic competitor of America is, indeed, facing a difficult proposition.

Other causes of American supremacy

could be mentioned, but none so fundamental as the four above named. Will these causes be permanent, or will British and German rivals adopt American weapons and beat Ameriacns with them? To do this will require more than mechanical or economic reforms. It will call for changes that reach into character and temperament. And even when those are accomplished there will remain America's unquestioned superiority in raw materials.

ARCHER BROWN, *Rogers, Brown & Company, New York.*

AMERICAN competition in the world's markets is recognised as an aggressive factor, but it would be unwise to assume that it is so well established that American manufacturers can safely rest satisfied with the work accomplished, and so cease from further efforts. Undoubtedly a wonderful change has taken place in mercantile conditions during the past few years, and the causes are naturally subjects for discussion. In my judgment, natural developments, or, perhaps it would be better to say that the development of natural resources, have been the most influential factors; but it is also true that human, or race characteristics, have played, and are playing, a most important part in this drama.

Great Britain wrestea from Sweden the supremacy in the world's iron markets by the discovery, in her borders, of iron ore and mineral fuel deposits and the processes by which they could be successfully used. As the ore became exhausted and the other more expensive of utilisation, it has been perfectly natural that another country, in which greater stores of both minerals existed, should, in its turn, wrest from Great Britain her supremacy in that industry.

These natural progressions may be delayed, but they cannot be absolutely prevented; and, while they nearly always bring distress upon the peoples from which existing things are passing away, it does not follow that there should not be hope for them on other lines. All men do not have to be ore miners, nor iron smelters, nor wheat raisers. But, when the mine fails, when the furnace is cold, and when the wheat field, of necessity, lies fallow, it is, for a time, hard to forecast a bright future for those who have been dependent upon those industries. The inevitable can often be hastened or delayed. It must and will come, but foresight and wisdom in action may make preparation for it.

Twenty years ago the cities of Albany and Troy were the centre of stove manufacture in America. About that time the competition of some westerly points began to be felt. While the stove manufacturers of Albany and Troy appreciated the danger, their skilled employees banded together in a strong Moulders' Union, ignored it, and argued that the then existing conditions could not be changed. Their locality was nearer the source of the pig iron supply, and could, therefore, always command cheaper iron; and, beyond all, no other points had the same moulding sand, and, without that, successful competition against Troy and Albany stoves was impossible. So strike followed strike. In many of these the men carried their points. The conditions governing the employment of apprentices, the hours of labour, and the amount of work produced per man were all satisfactorily controlled; but the development of the natural resources of the great American Northwest was not. To-day the blast furnaces of the Hudson River valley are a tradition, and the stove foundries of Troy and Albany are diverted to other uses, or else crumbling ruins; while those of Detroit, Aurora, Milwaukee, and other cities further west are echoing the thud of the rammer, the clank of the moulding machine, and the blast of the cupola.

While the stove makers and their families may have suffered through this change, both Albany and Troy have lived above their losses, and are to-day

more prosperous than ever. Had the inevitable been recognised, the change would have come slower and with less loss. That it caused so little loss, and that this was so quickly recovered, was because it happened in America. The Troy moulder's father most likely had been an agriculturalist in Europe,—perhaps it was his grandfather; but that was no reason why his son had to be always a moulder. Why not an alderman, or perhaps a mayor? Certainly not a pauper.

It must be remembered that while the stove manufacturing interests of Middle New York suffered, and those of Michigan, Illinois, and Wisconsin prospered, and from 800 to 1000 miles separated the districts, they were still parts of the same nation, and were connected by quick and cheap transportation. So it was, and is, impossible for one part of the American nation to enjoy continued prosperity without its beneficent influence being felt in some way, sooner or later, by all parts.

This equalising effect is more difficult and slower in operation when applied to nations, particularly if separated by miles of watery distance. Nevertheless, it works. Great Britain's colonies cannot suffer without affecting her, neither can they prosper without the mother country feeling the filial contributing hand. In the first place, the old countries cannot help being successfully met in the world's markets by American competition, owing to the natural workings of the world's development. In the second place, the success of that competition has come quicker and is prospering faster through the Troy-moulder-like mental characteristics of both master and man in those countries. To-day nothing in the commercial world can be assumed as being safe, and nothing must be put aside as being impossible.

ROBERT W. HUNT, *Robert W. Hunt & Company, Chicago.*

THERE are a number of causes for the possibility of successful American competition with the older industrial countries of Europe. The first one is the general cause which has brought the northern races to the front in modern civilisation. The greater the natural difficulties, such as climatic conditions, distances, and others, the greater will be the development in the strength and ability of the race which is to overcome them. This evolution had produced the most hardy and active races of Northern Europe, and from these the pioneers of the United States were recruited.

Greater rewards for persistent industry, a minimum of government interference with the enterprise of citizens, the greatest possible freedom from restraint in all directions, naturally attracted to the United States the most active, the most hardy, and the most ambitious of the young men of these races. The absence of class distinction, or horizontal stratification of society, made it possible for the most able in any profession or calling to rise to the highest positions. With the exception of a few of the larger centres of population, this feeling of perfect equality still obtains in our country, and I regard it as the greatest factor of all for continued progress and success.

Our great natural difficulties, vast areas, great rivers, dense forests and mountain chains made the development of our extensive railway system a necessity, and compelled us to cut loose from European precedents and develop on strictly American lines. For many years the wants of our rapidly growing railway system made development in all branches of mechanical industry necessary, remunerative, and of the broadest character.

Immediately following this came the immense growth of our electrical industries, giving a new impetus to almost every mechanical industry, and making specialisation necessary. The expansion of the copper industry, due to the demands of electricity, is often commented on. There are many other in-

dustries which owe it fully as much, although the direct connection may not be so apparent.

Our next great blessing lay in the high wages paid to labour, especially to skilled labour. This presented, first, one of those difficulties in the overcoming of which the human race is educated and elevated; and, second, a home market superior to any the world had ever seen. Seventy million aspiring Americans consume many times the products of blast furnace, steel works, flour mill, cotton and silk mill, furniture factory, fruit and dairy farm than 400,000,000 contented Chinese coolies; and the American mechanic, no matter of what race, works harder than his European colleague.

Mass production in every field of labour necessarily brought about specialisation. Those of us who remember the old foundry and machine shop of forty years ago, which *made* everything we could ask for, but *manufactured* nothing, understand, at a glance, why the modern specialised factory, which manufactures only one class of goods with special machines in every department, in the hands of specialists of every grade of labour, produces this one article at so small a cost.

While it is true that we, too, are developing, to some extent, a "leisure class," the fall in the rate of interest and the greater intelligent attention applied to the solution of our political burdens will be apt to reduce the number and influence of this class, so that in the future our hive will contain more workers and less drones than even at present.

Further intelligent specialisation, as close a study of the foreign markets as we have given to our home market, and persistence in broad Americanism in dealing with all workers in our industries, will, I think, ensure us, in future, the supremacy in the markets of the world. The further cheapening of mass production made possible by the great combinations, commonly called "trusts," will have an immense influence in the matter. There is, however, a danger lurking in these combinations which will first have to be eliminated. This is the tendency to make the financial management paramount, and by that measure to undervalue the mechanical specialist who has made all this development possible. But so sure as this is done, quality will deteriorate, the combinations will fail, and new ones, built up on the intelligent recognition of all the factors of the problem, will take their place. American success can be made permanent only by full recognition of all the forces which have brought it about, and complete co-ordination of the specialists who control them.

E. D. MEIER, *The Heine Safety Boiler Company, St. Louis, Mo.*

REPLYING to the question of the editor regarding reasons for the recent rapid extension of American engineering work throughout the world, it seems to the writer that, as is usual when great works are done, there is present a harmonious mixture of special ability and special opportunity.

The primal cause of such ability as has been manifested in the case in question is, perhaps, a certain strenuous spirit, so to speak, pertaining to the Anglo-Saxon race, which has enabled it to spread its language and its works all over the world, and to conquer much of the world's territory. His inherited "grit" and energy have been supplemented in the Yankee by a century or more of training, in meeting and conquering the natural difficulties in a new country, all of which has made him a very original mechanical genius. As a consequence, he is able to attack new problems in engineering and manufacturing fields from a broad and original point of view, answering each new problem by finding out how a thing ought to be done in the simplest and cheapest way, rather than by considering how it had been done previously.

This spirit and method of planning and performing work has enabled him

to systematise manufactures of almost every kind so as to make the products as uniform as possible and as simple as possible, both as regards their number of component parts as well as their conformation.

Furthermore, he has applied to their production, wherever possible, the system of interchanging parts, and the using of special tools, thus enormously decreasing the time and cost of many articles in comparison with older methods of producing them. Such contriving and using of special tools as practiced by the Yankee (this word being here used as typical of the ingenious, mechanically minded American) has been termed by the writer in a former article upon this subject the "jig-habit." This, of course, does not refer to the using alone of the tools technically called jigs, but also to many analogous devices which embody the grand principle of cheap multiplication of similar pieces by reason of the existence of a masterpiece of some kind, upon which all the ingenuity, original thought, and expense necessary to perfect it have been lavished.

This principle is well illustrated in the art of printing, where the expensive engraving, or combination of types, has enabled the cheap duplication, on an enormous scale, of the forms embodied in the original. The same idea is exemplified in the making of coins, and in the stamping of many articles from sheet-metal, the original dies being expensive and highly developed, but capable of producing millions of pieces, all alike, without further exercise of intellectual or artistic power. The same general conception is again seen in the elaborate tools which are mounted upon turret-lathes, where one careful adjusting answers for all the screws or rods which are to be made of a certain kind, without high mechanical skill being applied to the production of each, as in the old-time methods.

Still more is this principle shown in the using of jigs, cradles, and gauges for locating and keeping accurate all the holes and other finished surfaces in various pieces of wood or metal which formerly required much skill for individual production, but which are nowadays made by cheap labour with tools, on which latter the higher brain and manual art of the mechanician have been expended. The results of using the kind of tools referred to are seen in the enormous cheapening of such articles as sewing-machines, firearms, household utensils, agricultural machinery, and others.

It is true that the principle mentioned cannot be applied to all the articles which have recently swelled the exports of the United States to such an enormous volume, but the spirit of doing things after this manner, wherever possible, is " in the air " among American manufacturers, and the high-pressure habit acquired in the production of goods these processes has enabled Americans to turn out bridges, and locomotives, and canned foods, as well as thousands of other things, in accordance with the cheapest and quickest methods possible. These new styles of Americanisms have recently developed to an extent which has given Americans enough advantage over other exporting nations to show a volume of results of which, as a nation, the United States may well be proud.

In addition to the mechanical ability here considered, a considerable degree of commercial ability has also been exercised to procure orders for the things which had to be built, and to see that the engineering departments of the establishments doing the work were kept down to a cost as low as expressed by certain necessary predetermined figures. Here, again, we recognise, as important factors in the transactions referred to, the class of men sometimes known as " Yankee hustlers,"—men of unbounded energy and persuasive manners. Such men, with enormously large financial opportunities, sometimes become promoters of great " trusts." In medium transactions, they are likely to become negotiaters of larger or smaller foreign contracts. When confined to provincial environments and possessed of but narrow commercial education, they are apt to appear as simply suc-

cessful commercial travellers, or "bagmen," as they are called in Great Britain.

So much for the special ability referred to in the first paragraph. The other element necessary, special opportunities, seems to have existed more during the last five or ten years than ever before in the history of the world. Such opportunities are, doubtless, largely due to the rapidly increasing travelling habit, among both the American people and those of other countries, —also to the great publicity of modern business, as expounded through numerous popular and technical magazines and other publications. Coupled with all this is the generally prevalent spirit of betterment of public and private works, which now seems to be extending over the world, in the arts of peace as well as war,—let us hope with increasing preponderance in regard to the former.

OBERLIN SMITH, *The Ferracute Machine Company, Bridgeton, New Jersey.*

THE great advantage of America lies in the ambition of the American craftsman. Great may be our natural wealth of ore and coal, perfect our plants, inexhaustible our capital, but all of them will not keep us in the industrial leadership without the men who can, and will, make the best use of them all. One of the most successful manufacturers in the United States has been quoted as saying that if he had to choose between his great plants, on the one hand, and the organisation then working them, on the other, he would take the organisation. In other words, he considers the brains of his staff of greater value than his enormous and costly establishments.

How many of the men on whom he relies began life at the foot of the ladder? I cannot answer that question with knowledge, but those of us who know the men that have met success in American industrial work will make a "guess" that could be upset only by exact statistics.

A possibly interesting sidelight is thrown on the whole question by a recent conversation with a British friend, who, in speaking of Eton, said that one could not help being impressed with the fact that the great majority of the future ministers of Great Britain's government, of the coming generals of her armies, of the prelates to be in her historic Church, were there among those one thousand boys. And this of a school for which your son must be entered almost at his birth if you would get him in.

Of the other industrial nations we, naturally, have less knowledge than of Great Britain. Germany has always appeared to me to be our only other likely rival. Of Germany I have had to judge by the mechanics from that country with whom I have come in contact. There can be no question as to their skill and patience; their ambition, however, is not that of the American, though it does become so after they have been Americanised.

We owe our position to the fact that we are a manly, energetic race, whose sons have the chance to rise if they deserve promotion, and who, therefore, have the ambition. The danger seems to me to be that the new industrial developments which we see on every hand may reverse the condition which has heretofore been characteristic of our national life. If we are true to ourselves and our national traditions, I can see only one issue possible in the race for industrial supremacy.

COLONEL E. A. STEVENS, *President of the Hoboken Land & Improvement Co., Hoboken, N. J.*

CONTINENTAL STEAM ENGINES

AS SEEN AT THE PARIS EXHIBITION

By W. D. Wansbrough

The present article is practically a continuation of the one on the same subject by Mr. Wansbrough in the January number of this magazine.—THE EDITOR.

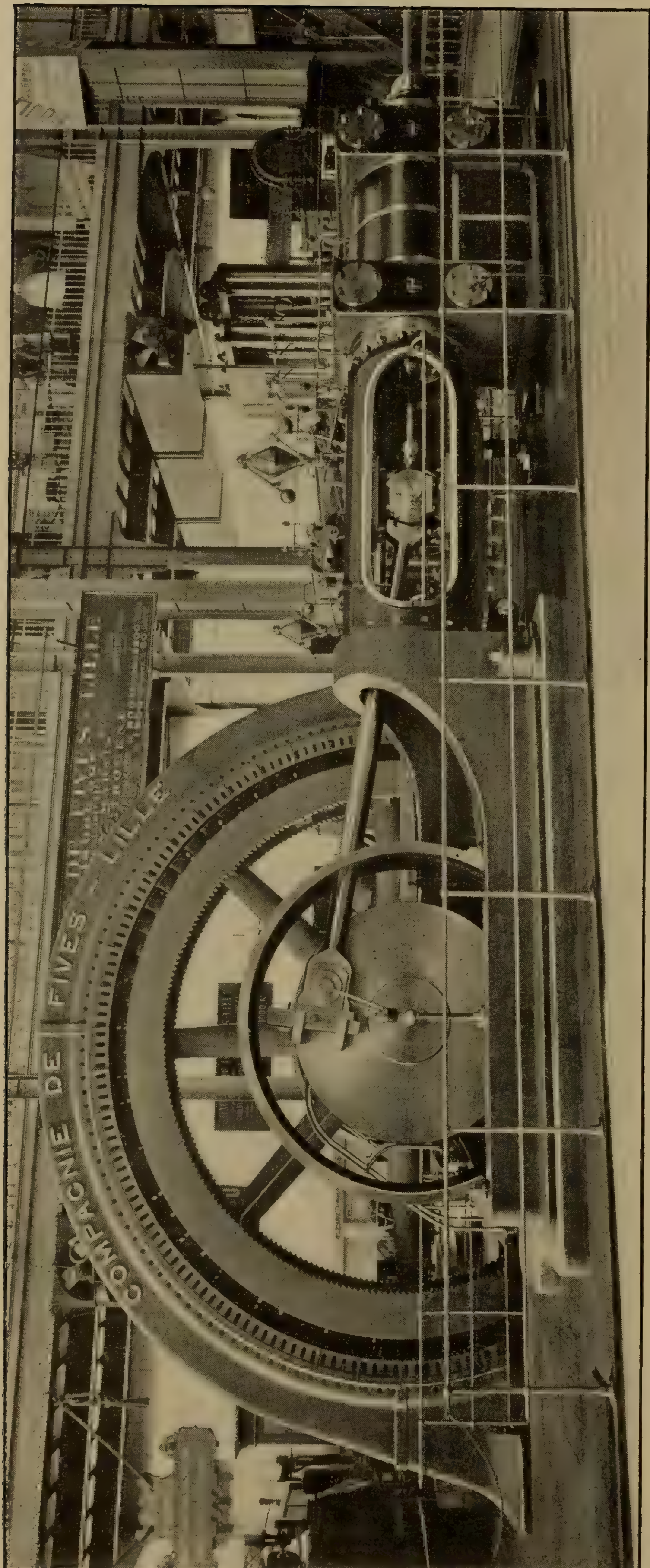
THE Compagnie de Fives-Lille, among their many exhibits at Paris in different departments, contributed to the electrical section a very fine 1200-H. P. Corliss engine driving a three-phase alternator of their own make. Of this a cut is given on the next page. It was a two-cylinder, horizontal compound engine, having cylinders 27½ and 51 inches in diameter by 55 inches stroke. The cranks,—cast-iron balanced discs,—were keyed at right angles upon the shaft, which carried at the centre an alternator fly-wheel of 34½ tons weight, making seventy-nine revolutions per minute, corresponding to a frequency of fifty periods per second in the three-phase current produced by the alternator. The weight of the revolving mass was sufficient to keep the variation in the angular velocity within 0.4 per cent., or $\frac{1}{250}$th of the normal speed.

The engine frames were of the Allis pattern, giving a broad and massive support to the crankshaft. Tubular guide-frames united these to the cylinders, which themselves rested upon base-plates, allowing free expansion and contraction. The distribution to both cylinders was of the Corliss type. The admission could be varied from 0 to 45 per cent. in the high-pressure cylinder, and from 12 to 60 per cent. in the low-pressure. The points of cut-off in both cylinders were controlled by the governors, of which there were two, identical in construction and revolving at the same speed, their sleeves being connected by a cross-shaft. The relative adjustments of the two governors were so fixed as to distribute the total work as equally as possible between the two cylinders, particularly at, or near, the normal load. Within the limits of the power for which the engine was designed the speed could be varied at will from 10 per cent. above to 10 per cent. below the regular speed.

Both cylinders were steam-jacketed. The high-pressure cylinder was formed in one casting with the jacket, through which the whole of the steam supplied to the engine passed on its way to the admission valves. From the high-pressure cylinder the steam passed through a tubular reheater on its way to the low-pressure cylinder, whose jacket was heated by the same steam, admitted by a separate valve. In the low-pressure cylinder the jacket was formed by the insertion of a separate liner or working barrel.

The condenser was installed below ground level. The air-pump was vertical, and, with the feed-pumps, was worked by a lever from the low-pressure crosshead. The main bearings were each 15¾ inches in diameter and 31½ inches long, and the central portion of the shaft, where it was swelled to receive the alternator fly-wheel, was 25½ inches in diameter. The width of the engine, measured from centre to centre of cylinders, was nearly twenty feet, which will give some idea of the liberal proportions accorded to this fine example of French workmanship.

MM. Dujardin & Cie, of Lille, showed four horizontal engines, namely a 1000-kilowatt, four-cylinder engine and Creusot alternator; a 500 kilowatt tandem and alternator (by the Société l Eclairage Electrique); and two compound engines

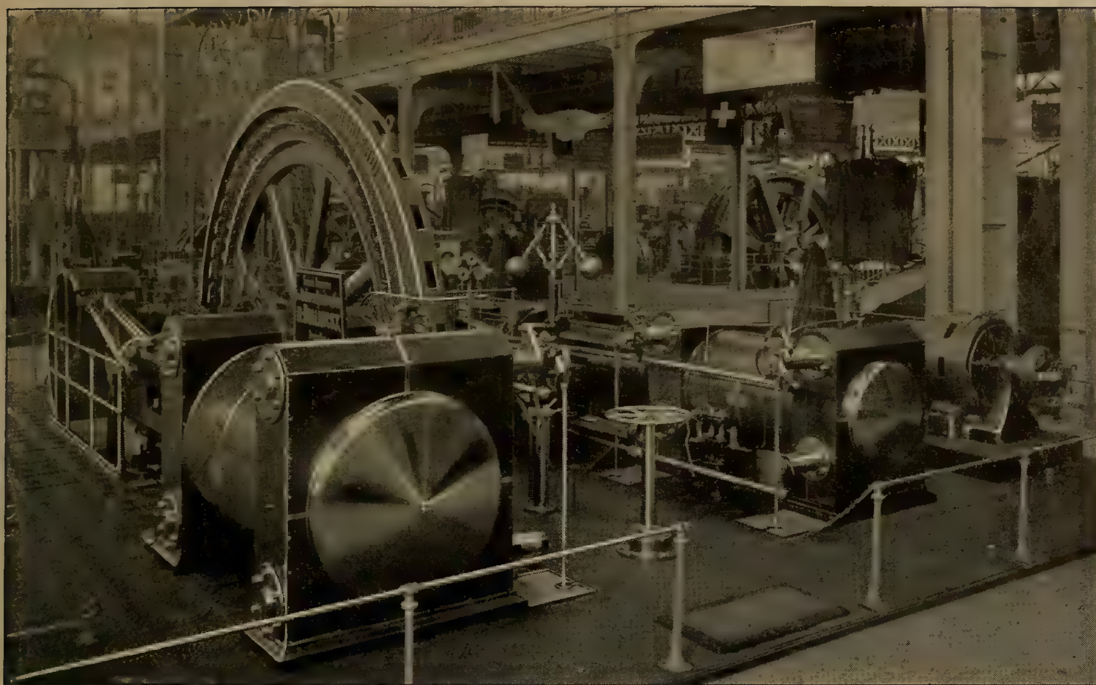


TWO-CYLINDER CORLISS COMPOUND ENGINE BUILT BY THE COMPAGNIE DE FIVES-LILLE

of 1200 H. P. and 300 H. P., respectively. These last two were exactly alike in design, and served to illustrate the firm's standard series in this type, of which they make seventeen sizes, ranging from $23\frac{1}{2}$ to 71 inches stroke.

The first mentioned of these engines, shown on page 390, was a triple-expansion, horizontal condensing engine, with two cranks set at 90° apart. The alternator acted as fly-wheel, and was placed centrally between the two bearings. It was of sufficient weight and diameter to keep the angular velocity within $\frac{1}{250}$th of the normal at its speed of seventy-two revolutions per minute.

There were two low-pressure cylinders, placed next the beds on each side of the engine, the high-pressure cylinder being attached tandem-wise on the right-hand side, and the intermediate cylinder occupying the corresponding position on the left-hand side. The bases upon which the cylinders rested were fitted with slides, which allowed of free lengthwise expansion and contraction. The valve gear of the high-pressure cylinder was constructed upon the well-known Dujardin system, with Corliss valves, both admission and exhaust valves be-



COMPOUND 1000 H. P. ENGINE BUILT BY H. BOLLINCKX, BRUSSELS

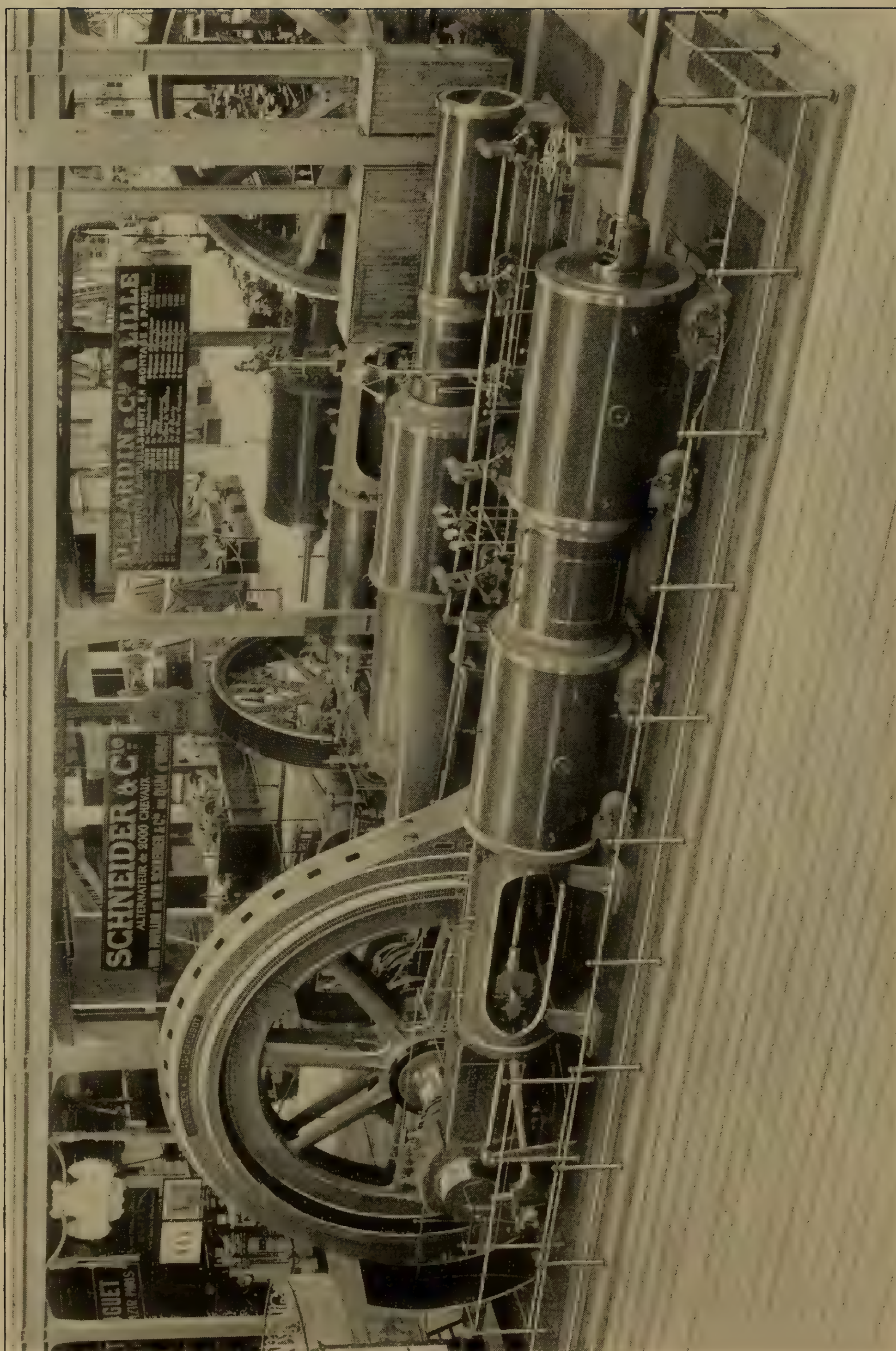
ing, in all cases, put underneath the cylinders. The gear was, of course, controlled by the governor, the intermediate and low-pressure valves, of identical construction, being adjustable by hand only. In the case of a breakdown of the high-pressure cylinder, however, the intermediate valve gear could be coupled up to the governor to take its place.

All the cylinders were steam-jacketed. The working barrels, or liners, were of specially hard metal, forced in and made steam-tight by segments of copper inserted in the joints. In the case of the high-pressure cylinder the boiler steam circulated around the jacket before entering the stop valve. The base and the covers were heated alike by live steam from a steam dryer which was inserted in the main supply pipe as near as possible to the cylinder.

The jacket spaces and bases of the intermediate and low-pressure cylinders, as well as the covers of the latter, were heated by expanded steam at eighty-five pounds pressure. In the same way were also heated the two receivers,—one between the high and intermediate cylinders, the other between the latter and the two low-pressure cylinders, an expansion joint being provided in each case, allowing of free expansion and contraction.

Each side of the engine had its own condenser and two air-pumps, the latter being vertical, single-acting, and provided with a number of small valves set in three concentric zones or rings. Each pair of air-pumps was worked by a T-shaped lever driven from the main crosshead on that side of the engine, the pumps being thus alternate in their action. The condensers were below ground, and had, in addition to the ordinary injection pipe with its distributing cone, a small valve, easily accessible, by which, in case of failure of the ordinary supply, the pumps could be instantly charged with water. Two self-acting relief valves, worked by floats, were placed in each condenser, at different heights, for the purpose of preventing the flooding of the cylinders, should the water level rise too high in the condenser, in which case communication was opened with the atmosphere and all danger avoided. Three-way exhaust valves were also provided, by which the engine could be worked non-condensing if required.

The cranks were pressed on the shaft with a force of 285 tons, by hydraulic pressure, the crank pins and crosshead

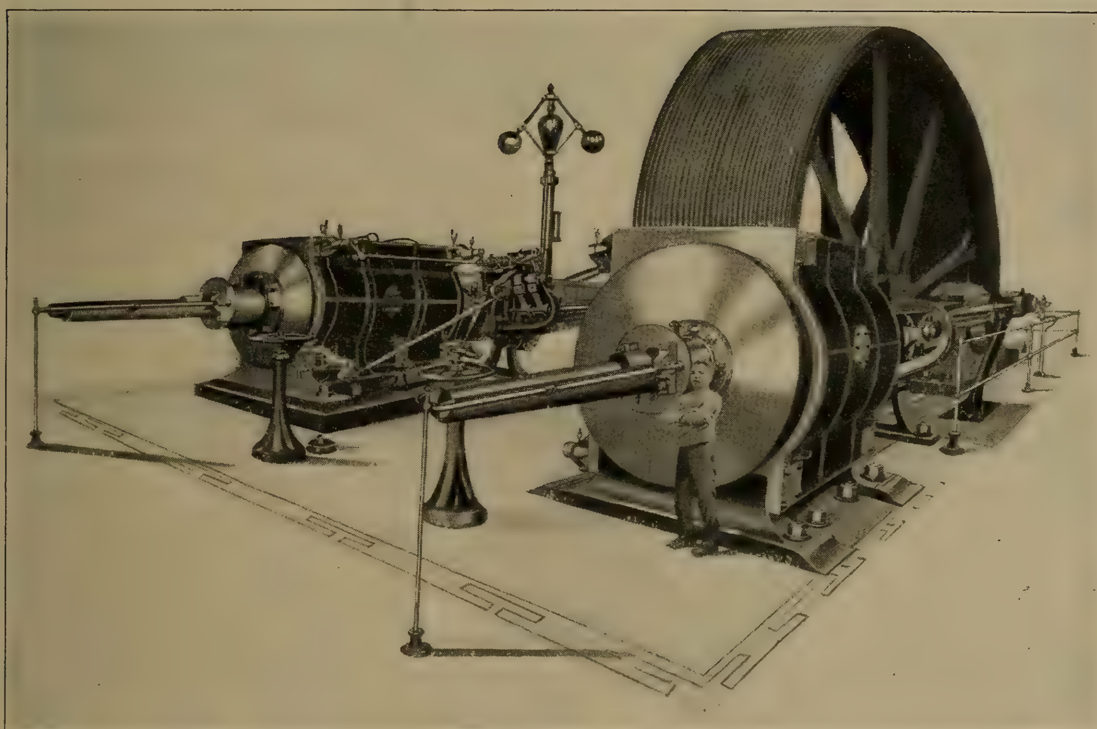


FOUR-CYLINDER TRIPLE EXPANSION ENGINE BUILT BY MM. DUJARDIN & CIE., LILLE

pins being similarly treated, with proportionately less force, no keys being employed. The lubrication of the cylinders was effected by small oil-pressure pumps worked by the engine, and all the moving parts were also continuously lubricated, whilst in motion, by rotary pumps placed upon the floor at each side of the engine. All the valves and cocks were worked from a system of levers conveniently placed between the cylinders.

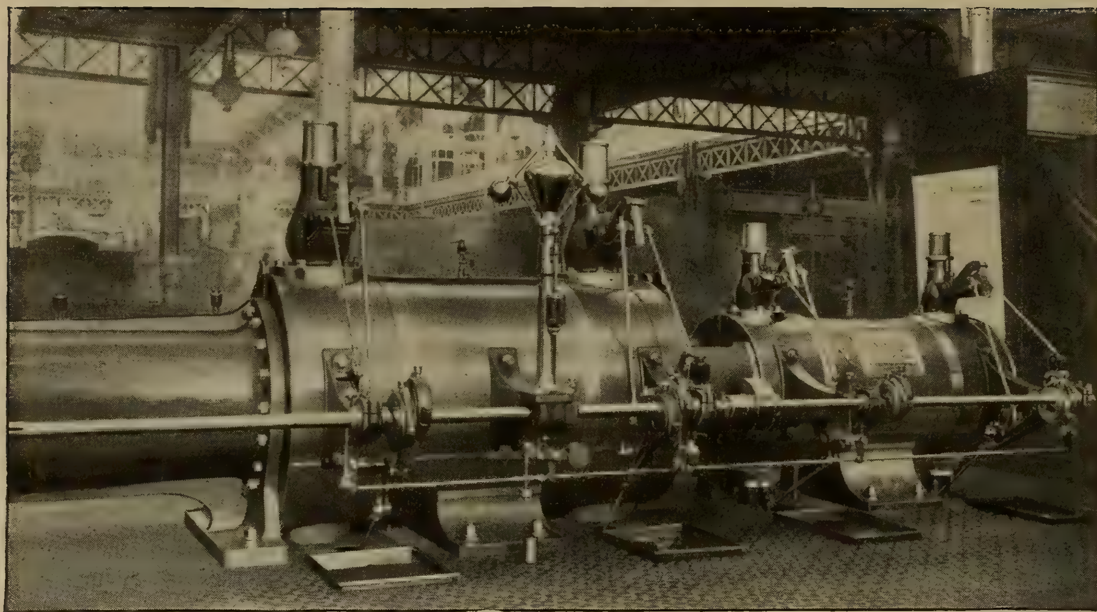
In striking contrast to its sombre-coated neighbours in black and grey, the vivid scarlet of the 1000-H. P. engine exhibited by the Belgian firm of H. Bollinckx arrested the attention of every passer-by, and formed a distinctly useful landmark or rendezvous. "Meet me by the red engine at twelve," was a not infrequent form of appointment when parting with a friend in the machinery hall.

There were, it appears from a circular issued by the makers, no less than thirty-two reasons why one should purchase a "Bollinckx compound" in preference to any other engine, one of them being the fact that its characteristic colour compelled the attendant to keep it in spotless condition on pain of instant detection by the vigilant owner. The engine was a two-cylinder, horizontal compound, with vertical air-pump and condenser, combined with a dynamo by the Société Anonyme Electricité et Hydraulique, of Charleroi. It formed an interesting departure from the prevailing system of triple-expansion, high-pressure, and superheat, all of which are anathemas in the Ateliers de Construction H. Bollinckx. Nevertheless, they were able to guarantee a steam consumption of 11.8 pounds of steam per H. P. per hour, using saturated steam at 110 pounds pressure, with a total expansion ratio of 4.6; the cylinder volumes being as 2.3 to 1, and the normal cut-off in the high-pressure cylinder being one-half. An engine precisely similar to that exhibited had been certified by the Belgian Association for the Survey of Steam Boilers as giving such a result. The makers attribute this excellent performance to the following constructive features:—



CORLISS COMPOUND ENGINE BUILT BY MM. CRÉPELLE & GARAND, LILLE, FRANCE

1st.—The small amount of clearance, under 2 per cent. of the cylinder vol-

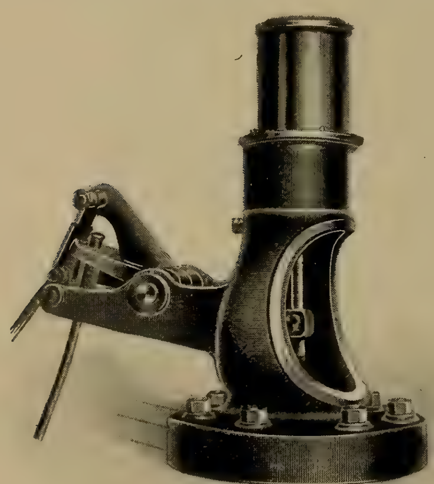


TANDEM COMPOUND ENGINE OF THE VAN DEN KERCHOVE COMPANY, GHENT, BELGIUM

ume, attained by casting the Corliss valve chambers in one piece with the cylinder itself at one end, and in one piece with the lever at the other, a single flange joint connecting the two.

2d.—The efficacy of the steam-jacketing. The exterior surface of the liner is ribbed, and the covers are also jacketed. Each cylinder is heated all over in this way by its own working steam.

3d.—The engine is much lighter than an engine built for higher pressures. Hence the losses by engine friction are reduced to a minimum. The foundations also are much less costly than for a more complex engine.



TRIP GEAR OF THE VAN DEN KERCHOVE ENGINE

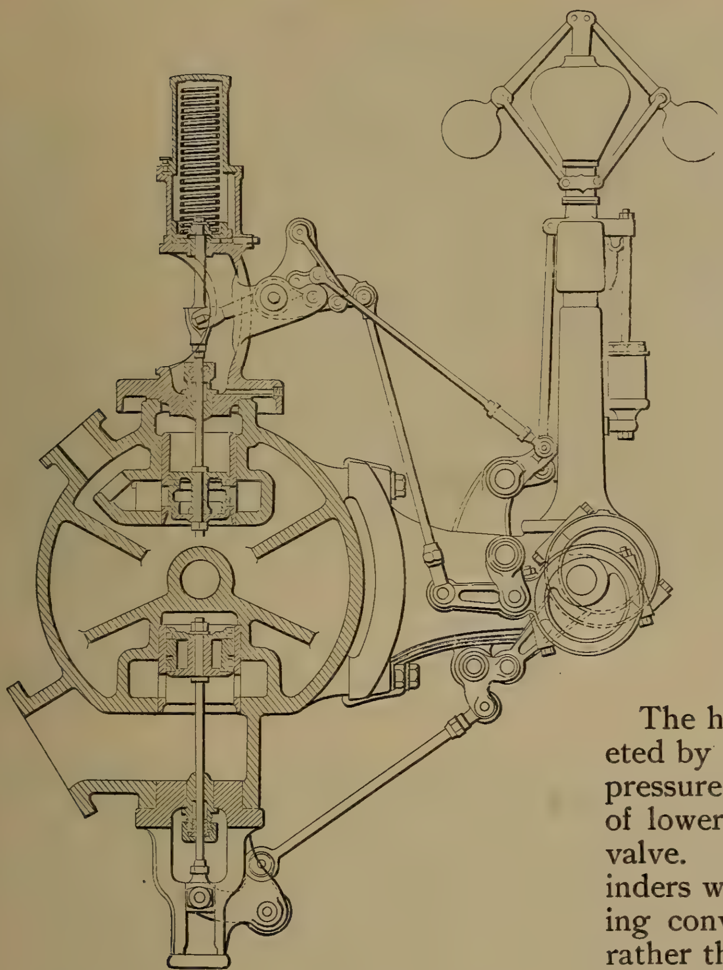
4th.—The efficiency of the lubrication. Oil is circulated through the bearings by a small pump, and the crosshead slides, too, are supplied with oil under pressure. Water also circulates about the main bearings, keeping them always cool.

5th.—The construction of the Corliss valves; the absence of all packing throughout the engine, except for the piston rods; the accuracy of the shaping and fitting of all the parts; and the general high finish; all doubtless contribute to the attainment of what appears to be a striking degree of economy.

The firm of Bollinckx has long been celebrated for its minute accuracy in matters of detail, as well as for its aversion to the use of keys as fastenings, not one of which is to be found in the engine under notice. The principal dimensions are as follows:—

Diameter of high pressure cylinder	30	in.
" low " "	45½	in.
Stroke	59	in.
Revolutions per minute	80	
Piston speed, feet per minute	785	
Diameter of main shaft at centre	19.7	in.
" " " journal	11.8	in.
Diameter of air pump	39⅜	in.
Stroke " "	10¾	in.

MM. Crépelle et Garand, of Lille, showed a large Corliss compound engine of the type illustrated on page 391, but



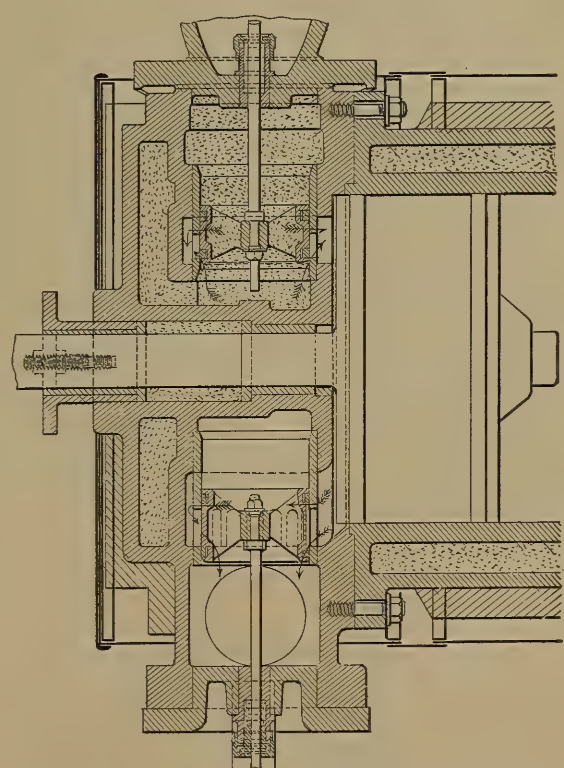
CROSS SECTION THROUGH ONE OF THE VALVE CHESTS OF THE VAN DEN KERCHOVE ENGINE

tion, the cylinder feet, as well as the supports under the trunk guides, though resting upon similar base-plates, being free to slide longitudinally, to the avoidance of expansion and contraction stresses. The bearings themselves were of cast iron, in four parts, lined with white metal and lubricated by a centrifugal pump, which circulated the oil through a water-jacketed cistern in sufficient quantity to ensure that the bearings were effectually cooled. This plan appeared to be an improvement upon the separate water circulation through the bearings found in many of the Exhibition engines.

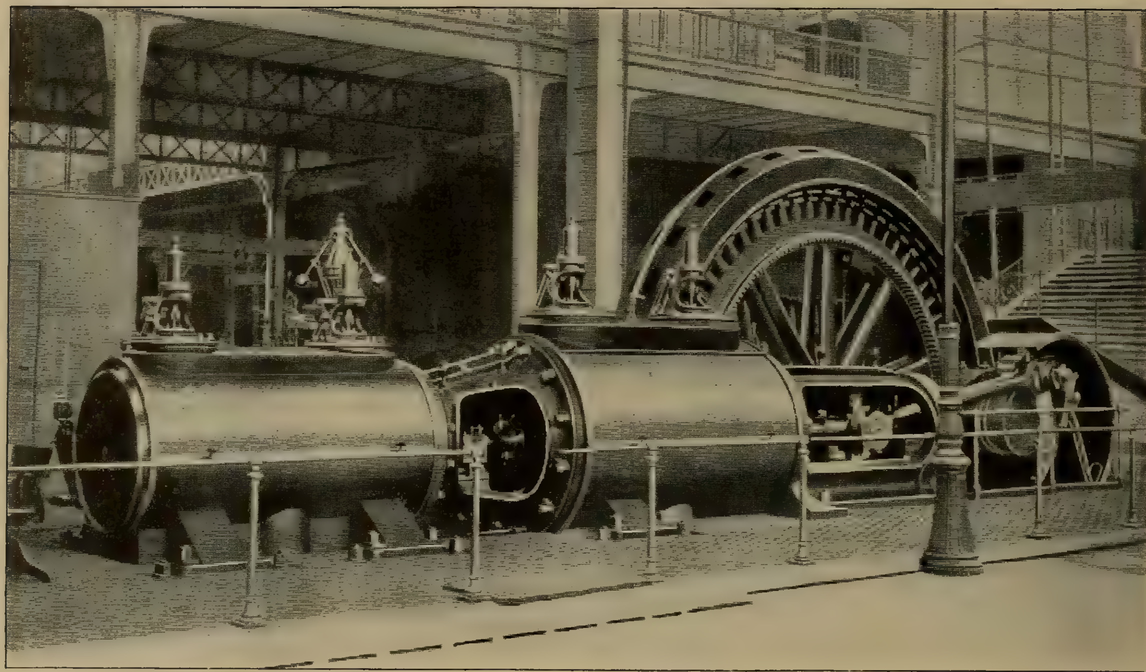
The high-pressure cylinder was jacketed by boiler steam all over; the low-pressure cylinder was heated by steam, of lower pressure, through a reducing valve. The receiver between the cylinders was not heated, experience having convinced the builders that loss, rather than gain, results from jacketing

combined with a dynamo, or rather a pair of dynamos, by the Société Decauville, mounted one on either side of the fly-wheel. The engine itself was a very fine piece of work, and had cylinders 28 and 52 inches in diameter by 63 inches stroke, making seventy revolutions per minute, and developing 1200 indicated horse-power with a steam pressure of 128 pounds, and with a cut-off equivalent to one-fifteenth of the volume of the low-pressure cylinder.

The external diameter of the fly-wheel was 20 feet 5 inches, in two parts, cottered at the rim and hooped and bolted at the boss. The crankshaft was a hollow steel forging, and was fitted with shrunk-on steel cranks keyed on at right angles, with crank-pins forced in by hydraulic pressure. The main bearing plummer-blocks were unusually massive, and were bolted to cast-iron base-plates firmly fixed to the founda-



ANOTHER VIEW OF THE ADMISSION AND EXHAUST VALVES



TANDEM COMPOUND ENGINE BUILT BY MESSRS. CARELS BROTHERS, GHENT, BELGIUM

the receiver. It was, however, well clothed with non-conducting material.

Liners of specially hard metal were forced into both cylinders. The pistons were fitted with three rings, upon the Swedish system, and the piston rods were prolonged to pass through the back cylinder covers. These tail-rods were supported by swivelling bearings outside the stuffing-boxes, lined with white metal, and adjustable as to height.

The valve gear was of the type known outside of France as the Wheelock system, with some changes peculiar to this firm, one of them being the method of actuating the semi-rotating valves by spindles which do not pass through them, the effect being that the valves are quite free to seat themselves without risk of being bound or " hung up " by the spindles. No packing is required, hardened collars on the spindles working in steam-tight contact with bosses formed on the covers. The condenser was placed, as usual, below ground. The governor was of the Watt type, but fitted with a central weight.

The 100-H. P. tandem engine of Van den Kerchove, of Ghent, had for its special characteristic the newly designed steam and exhaust valves which this firm are now making a prominent feature of their manufacture. The principle of this new system is the employment of pistons, instead of double-seated drop-valves, working vertically in cylindrical chests embodied in the covers at each end of the cylinders. The valves are fitted with plain steel rings, and the ports are simply a series of slots in the liners of the valve boxes, opening into annular recesses which communicate directly with the interior of the cylinder. The result is a reduction of the clearance spaces to the minimum of possibility; a perfect drainage of the cylinder by the lower or exhaust valves; the smallest possible exposure of valve-chest surface to the entering steam; perfect equilibration of the valves; and a total absence of shock when they are brought to rest. The sharpness of the cut-off is increased by the comparatively high speed at which the valves pass the ports before being brought to a standstill.

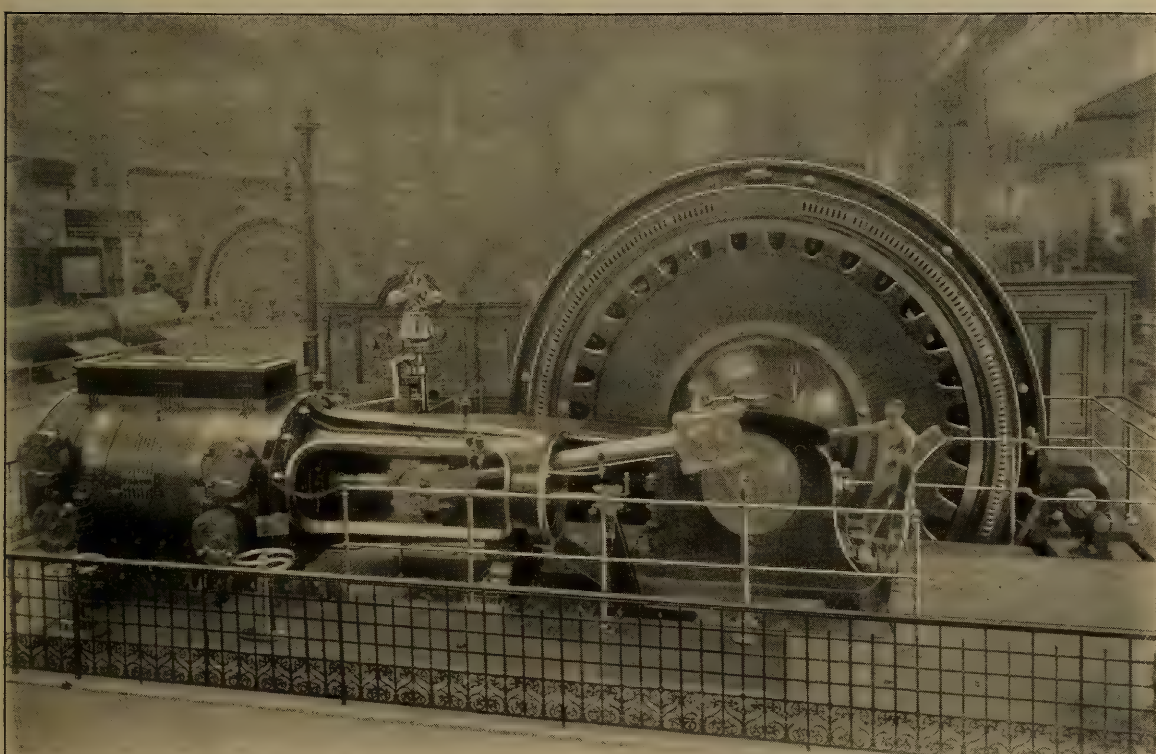
The cross-sections on page 393, give an excellent idea of the valves and the gear for working them. It will also be noticed that live steam surrounds both valve boxes, and, at the same time, heats the cylinder cover itself. The baffling action of the ribs seen in the upper view tends to knock out any

water which may enter with the steam. Altogether, the makers may be congratulated on the success which is likely to attend their new system. The principal dimensions of the engine are:—

Diameter of the high pressure cylinder	24¾ in.
" " low " "	43 in.
Stroke	47¼ in.

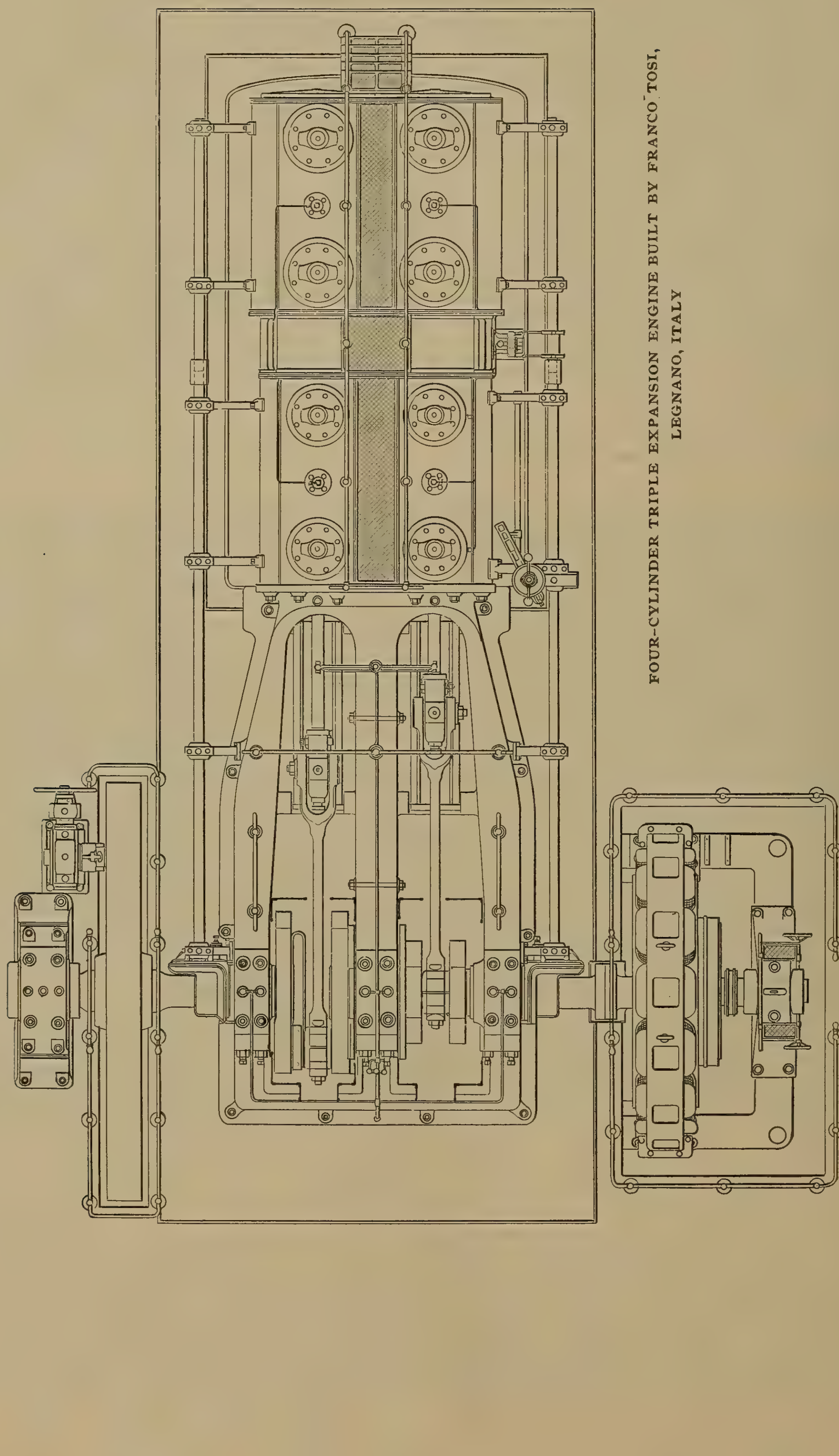
The normal speed of this size of engine would be 100 revolutions per minute, giving a piston speed of nearly 800 feet per minute. At this rate, with 132 pounds steam pressure and a total expansion of thirteen times the volume introduced, the indicated horse-power would be 1000. At the Exhibition, however, to suit the alternator mounted on the engine shaft, the revolutions were reduced to eighty-three per minute.

Carels Frères, of Ghent, showed a splendidly finished horizontal tandem, with cylinders 25½ and 41¼ inches in diameter by 45¼ inches stroke. An illustration of it is given on the opposite page. Like the one just described, this engine ran at a reduced speed at the Exhibition on account of the alternator (by Kolben, of Prague), to which it was directly coupled. The normal speed was 100 revolutions per minute, and, with thirteen expansions, it was equal to a duty of 1100 effective horse-power. The weight of the alternator fly-wheel is sufficient to ensure that the variation in the angular velocity shall not exceed one-half per cent. The main bearing was 15¾ inches in diameter by 29½ inches long, of cast iron, lined with white metal, an arrangement for circulating cold water round it being provided. The cylinders were both steam-jacketed around the bodies, but the covers were not heated in any way. A gap in the foundations, spanned by the remarkably wide bracketed feet of the cylinders resting upon planed cast iron strips or plates, allowed access to the exhaust valves and their gear from beneath. This arrangement gave a very snug appearance to the engine, but it is questionable whether, in practice, the out-of-sight parts of the engine will receive their due share of attention.



HIGH-SPEED SINGLE-CYLINDER ENGINE BUILT BY JOSEPH FARCOT, ST. OUEN, FRANCE

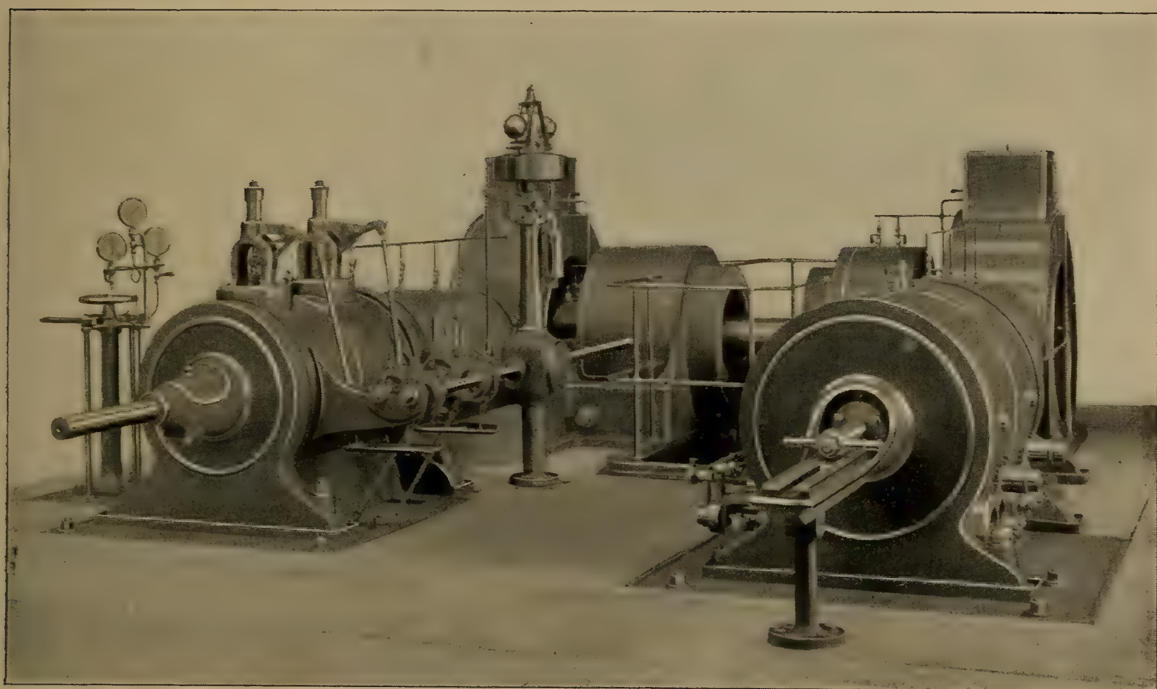
The valve gear was worked from a



FOUR-CYLINDER TRIPLE EXPANSION ENGINE BUILT BY FRANCO TOSI, LEGNANO, ITALY

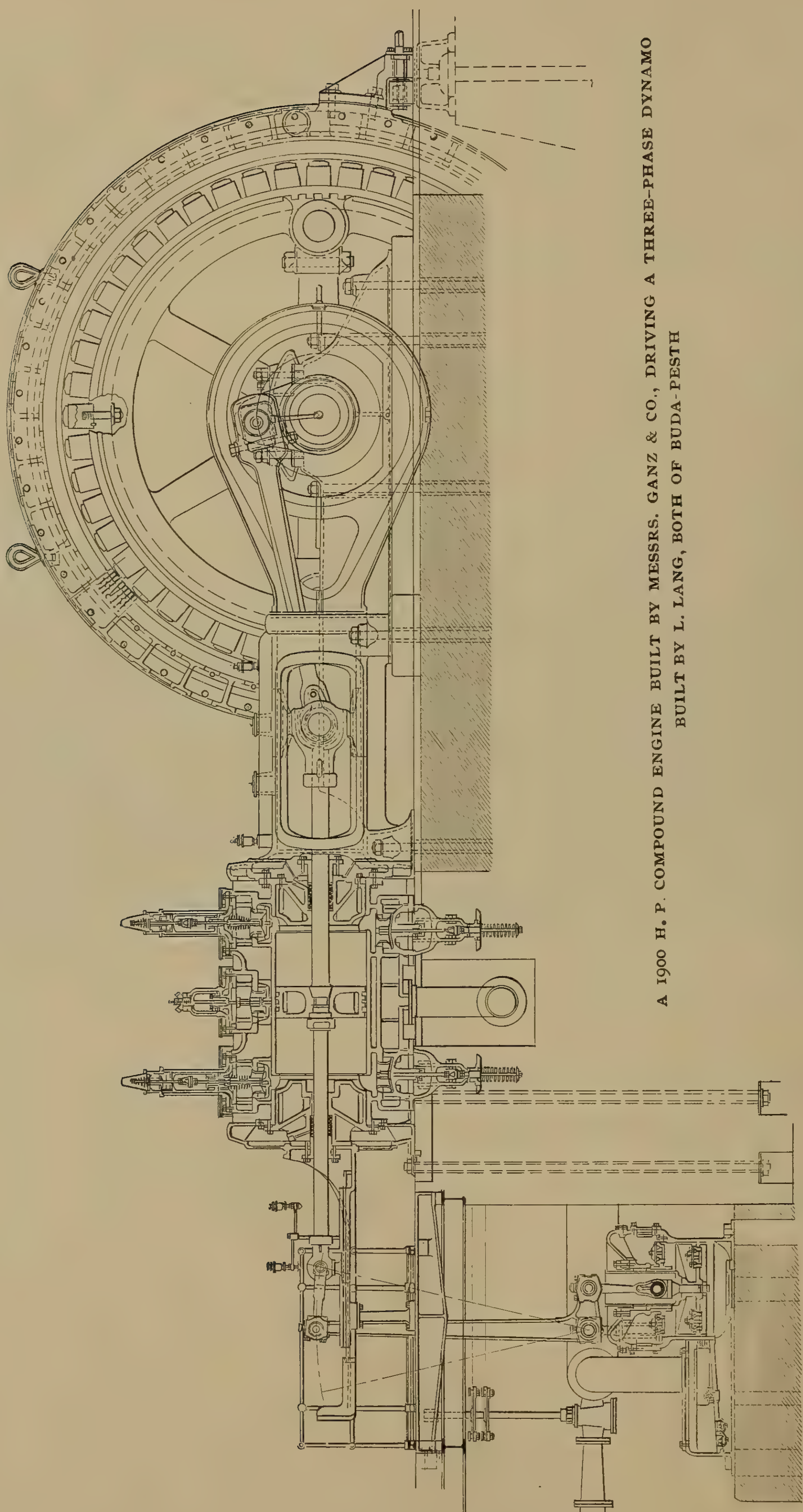
line shaft, not seen in the illustration, one eccentric serving to give motion to both steam and exhaust valves at each end of the cylinder. The double-seated equilibrium valves used by the firm seemed to the writer as being unusually large in diameter, owing to which, of course, a reduced lift becomes possible. The low-pressure steam valves were not fitted with trip gear, but their spindles were jointed by a short, curved arm to the eccentric rods. As the eccentric rod descends, this curved arm comes into contact with the flat surface of a bracket projecting from the dashpot, and the valve begins to lift. The curved arm now rolls upon the bracket, the effective fulcrum thus moving further away from the valve, with the result that the latter is lifted more and more rapidly as the eccentric rod descends. Upon the upward stroke of the rod the valve closes very rapidly at first, then more and more slowly, and is gently deposited upon its seat, any further upward movement of the eccentric rod merely lifting the curved arm clear of the bracket. The low-pressure exhaust valves also were worked by a modification of this principle.

The high pressure valves were tripped by a lever under the control of the governor which interposed a hardened steel roller when the cut-off was to take place. The simplicity and smoothness in action of this gear left little to be desired. It had also an unusual range, the admission period being variable through 75 per cent. of the stroke. The condenser, below ground, was of the horizontal type, double-acting, and worked from the crank-pin by an L-shaped lever. The support, or pad, under the piston rod in the casting connecting the two cylinders was a modern fashion, now much in favour on the Continent.

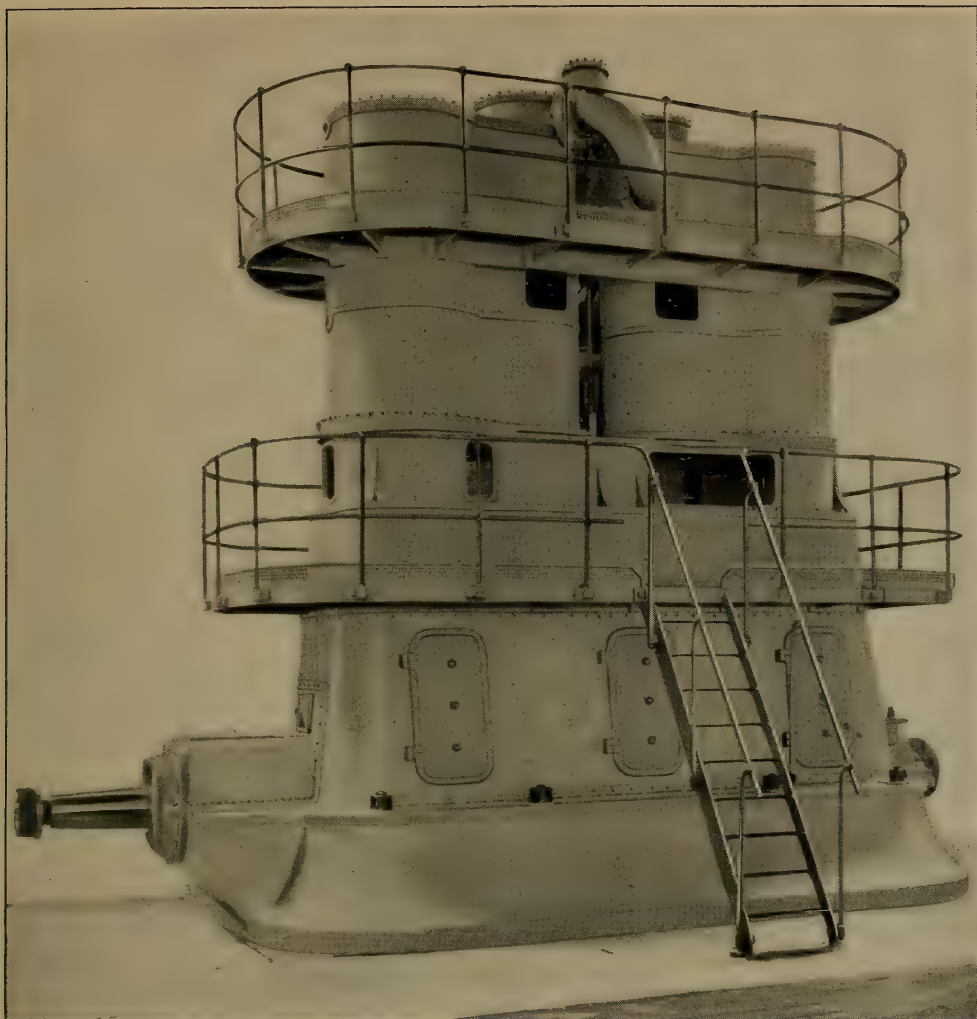


COMPOUND ENGINE BUILT BY THE PRAGER MASCHINENBAU-ACTIEN-GESELLSCHAFT, PRAGUE

Quick-speed, single-cylinder, horizontal engines are rather a feature in French practice, and an excellent example of this type was shown in the exhibit of Joseph Farcot, of St. Ouen. This old established and well-known firm were the makers of the alternator as well as of the engine, and both were finished off in the most elaborate style, the whole of the working parts of the engine being nickel-plated, while the alternator was resplendent with glittering brass-work. While the ornamentation was, if anything, a little overdone,



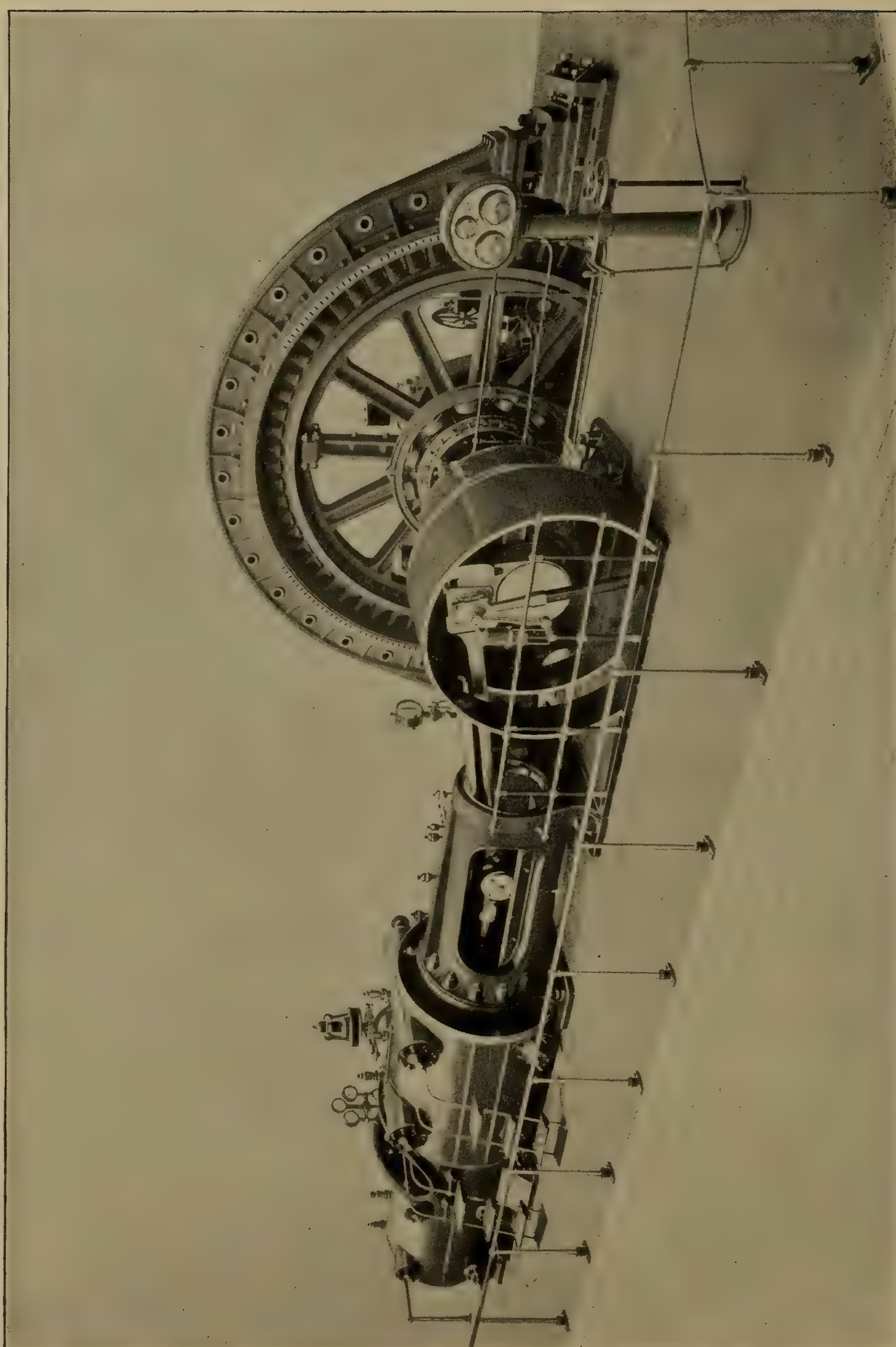
A 1900 H. P. COMPOUND ENGINE BUILT BY MESSRS. GANZ & CO., DRIVING A THREE-PHASE DYNAMO BUILT BY L. LANG, BOTH OF BUDA-PESTH



FOUR-CYLINDER TRIPLE EXPANSION ENGINE BUILT BY MM. DELAUNAY, BELLEVILLE & CIE., ST. DENIS

the simplicity of the design was commendable. Working with 85 pounds steam pressure and condensing, this single-cylinder, short-stroke engine was certified for a steam consumption of 12¾ pounds per horse-power per hour. The makers also stated that, with the respective admissions of one-tenth, two-tenths, and three-tenths of the stroke, the effective horse-power was 700, 1020, and 1230. The principal dimensions are:—Diameter of cylinder, 39⅜ inches, and stroke, 53 inches. The revolutions per minute were 79. The diameter of the alternator fly-wheel was 18 feet, and its weight complete was 48.9 tons. A cut of the engine appears on page 395.

The valve gear was of the Corliss type, and free from all unnecessary complication. The position of the steam and exhaust valves in the cylinder covers will be noticed. The additional length thus apparently imparted to the cylinder somewhat disguised its real proportions, the stroke being only 1.35 times the diameter, and one would be inclined to say that a better drainage would be effected by keeping the exhaust valves well below the bottom of the cylinder. The obvious defects of single-cylinder engines working with a high degree of expansion, namely, the great range of temperature in the cylinder, the shock upon the piston of such large diameter, and the almost unavoidable irregularity in the angular velocity, appear to have been as far as possible eliminated in the example before us. Still the writer cannot help thinking that the addition of a separate high-pressure cylinder, placed tandem-wise with the present one, would be of considerable



A 1000 H. P. TANDEM COMPOUND ENGINE BUILT BY MESSRS. ESCHER, WYSS & CO., ZURICH, SWITZERLAND

benefit, both as regards economy and regularity of rotation.

The Prager Maschinenbau Actien-Gesellschaft, formerly Ruston & Co., of Prague, showed a compound engine (see page 397), which, though of small size, deserves a short notice on account of its excellent workmanship and the common-sense principle of its design and arrangements. The engine exhibited, with its three-phase alternator, had been constructed to the order of the Austrian Government for the lighting of the railway depot of Pilsen, in Bohemia. It was a horizontal, two-crank compound, with cylinders 14½ and 23½ inches in diameter, and 27½ inches stroke, and ran at 150 revolutions per minute. With 147 pounds steam pressure and condensing, it was equal to a duty of 240 electrical horse-power at a speed of 120 revolutions only.

Both cylinders were jacketed, the high with boiler steam, and the low with steam at receiver pressure. The small cylinder was fitted with lifting valves for steam and exhaust, while the large cylinder had Corliss valves for both. Both sets of Corliss valves were placed underneath the cylinder, and worked direct from one eccentric rod without the intervention of a wrist-plate.

The high-pressure lifting valves were driven by a mechanism similar in principle to that used upon the low-pressure cylinder of the Corliss engine shown on page 394. Referring to the illustration on page 397, it will be seen that the valve stem is raised by depressing the obtuse-angled, bell-crank lever pivoted to the dashpot stand, while a double-armed lever, attached to the eccentric rod, is also pivoted to a bracket higher up the dashpot. The rising of the eccentric rod causes the tail of the latter lever to press upon the extremity of the obtuse-angled lever, but near its own fulcrum. Continued rising of the eccentric rod shifts the point of contact of the two levers nearer and nearer to the fulcrum of the obtuse lever, thus rapidly increasing the lifting speed, while on the return stroke the descent of the eccentric rod rapidly lowers the valve at first, the motion becoming slower and slower, depositing the valve gently on its seat. Any further depression of the eccentric rod simply lifts its lever clear of the valve lever. The valve is not tripped, but the duration of its lift is varied by the governor in this way:—The lower end of the eccentric rod is not attached directly to the eccentric, but to the inner extremity of a horizontal, two-armed rocking lever, the outer end of which forms the eccentric strap, while its fulcrum is itself an eccentric which the governor partly rotates. The exhaust valve is moved by the same eccentric as the steam valve, and by a similar arrangement of compound levers. The motion is an exceedingly quiet and durable one.

Lifting valves were preferred for the high-pressure cylinder, as being more suitable for superheated steam, also because leakage from the presence of a foreign body between the valve and its seat is of less consequence than in the low cylinder. On the other hand, Corliss, or semi-rotating, valves were preferred for the latter on account of their quick and noiseless movement, their absolute security against leakage, and the tendency of the valve to push on one side any particles which may fall upon the seat.

Messrs. Ganz & Co., of Buda-Pesth, showed, in conjunction with the firm of L. Lang, of the same town, a 1900 horse-power, horizontal compound engine driving a three-phase dynamo, by the latter firm. The high-pressure side of this engine is so clearly shown in the illustration on page 398 that little beyond recording its dimensions needs to be done here. The cylinders were 28½ and 45 inches in diameter by 35½ inches stroke. The high-pressure cylinder was jacketed with boiler steam, the low, with receiver steam, the jacketing of both being extended to the covers as well as the bodies. The air-pump shown in the illustration was duplicated on the low-pressure side, and, as will be seen, was of the bucket-and-plunger type, the buckets being 25½ inches, the plungers 11 inches, and the stroke 23¾ inches.

We now come to the 1250 horse-

power, triple-expansion, enclosed vertical engine shown by MM. Delaunay, Belleville & Cie., of St. Denis (see page 399), driving a three-phase Breguet dynamo. This was a four-cylinder, two-crank engine, the dimensions being: —High-pressure cylinder, 19¾ inches; intermediate cylinder, 32¼ inches; and two low-pressure cylinders, each 33½ inches in diameter. The stroke was 15¾ inches, and the engine ran at 250 revolutions per minute.

Forced lubrication was employed, the crankshaft being perforated throughout its length, the oil-channel passing up the throws and through the crank-pin journals. The connecting rods and eccentric rods are also hollow, the oil being forced, under pressure, into every bearing and pin throughout the engine by means of an oscillating pump outside the casing, and therefore readily accessible, worked by a small crank-pin on the end of the crankshaft.

All of the distributing valves were of the piston type, worked by two eccentrics. Both low-pressure cylinders were directly attached to the top of the casing, the high-pressure cylinder above, on the right-hand side in the illustration, the intermediate cylinder on the left. The clearance spaces in the high-pressure cylinder, owing to its piston valve being in line with that of the low-pressure cylinder beneath it, seemed excessively large; but the writer has no particulars of the steam consumption, so that he must refrain from criticism on this point, merely remarking that there are 500 clearances to fill with high-pressure steam per minute. The external appearance of the engine was plain and neat. Apparently the only means of access to the long gland between each line of cylinders was by lifting off the upper cylinder and taking off the piston.

An engine of quite a different type from any of the horizontal engines thus far described was that of the firm of Franco Tosi, of Legnano, near Milan. This Italian engine may, perhaps, be best described as a marine, double-cranked, four-cylinder vertical, laid horizontally, with a Schuckert dynamo mounted at one end of the crankshaft, and a 20-ton fly-wheel at the other, about 20 feet apart. It should, however, be mentioned that the engine was built to drive two dynamos, one at each end; but as no notice to that effect was exhibited, the casual visitor simply wondered and passed along.

For a change, we have here the high and intermediate cylinders placed next the beds, with the two low-pressure cylinders tandem-wise behind them. The cranks were at right angles, and were built up, as in marine practice, but had balance weights forged in one piece with the throws. The dimensions were, —high-pressure cylinder, 20¾ inches; intermediate, 32½ inches; two low-pressure cylinders, 36½ inches in diameter; stroke, 47¼ inches. The engine ran at 107 revolutions per minute, giving the very high piston speed of 845 feet per minute.

With 177 pounds steam pressure, this engine was calculated for a duty of from 1200 to 1500 horse-power. There were five main bearings, and an exceedingly elaborate system of lubrication was provided, as indeed was necessary with such a speed and such a length of crankshaft. All the cylinders were jacketed with direct boiler steam, the whole steam supply passing through the high-pressure jacket on its way to the stop-valve.

Equilibrium lifting valves were employed throughout, but the governor acted only on the high-pressure valves. The normal number of expansions was fourteen, and the steam consumption was stated at 11.66 pounds per horse-power per hour. Condensation was, of course, employed. The air-pump was vertical, driven from the crank-pin next the fly-wheel.

The Swiss firm of Escher, Wyss & Co., of Zürich, showed a 1000-H. P. tandem engine of their well-known construction driving an Oerlikon dynamo. (See page 400.) The valve gear was of their Corliss pattern, and was controlled by a small, but powerful, high-speed governor, running at four times the speed of the main shaft. The cylinders were 25½ and 43¼ inches in

diameter, by 47¼ inches stroke, and the speed was 105 revolutions per minute. The crankshaft was 15¾ inches in diameter at the main bearing, and the length of the journal was 29½ inches. The bearing itself was of cast iron, lined with white metal, and lubrication was effected, as usual, by a circulating oil pump.

The high-pressure cylinder was jacketed with live steam, and the low-pressure cylinder with receiver steam,—an arrangement well-nigh universal in modern engines. The condensing plant was below ground level, the air-pump being horizontal and double-acting. It was worked from the crank-pin through a bell-crank lever and link. The whole design of this engine was, as might have been predicted, most excellent, massive and rigid, without being clumsy. The workmanship and finish left nothing to be desired.

The Sulzer exhibit has been reserved for the last, and with it this survey of the engines at the Paris Exhibition of 1900 closes. Unfortunately, space does not permit of doing much beyond simply cataloguing the items shown by Messrs. Sulzer Brothers, of Winterthur, Switzerland, which are as follows:—

A horizontal, four-cylinder, triple-expansion engine, with fly-wheel alternator by Messrs. Brown, Boveri & Co., of Baden, Switzerland. This engine was rated at 1700 indicated horse-power, or 1500 effective, with 160 pounds steam, cut-off at 30 per cent. in the high-pressure cylinder. With a 40 per cent. cut-off, 1950 I. H. P. is developed. The principal dimensions are as follows:—High-pressure cylinder diameter, 23½ inches; intermediate cylinder, 33½ inches; two low-pressure cylinders, 40 inches each; stroke, 59 inches; revolutions per minute, 85. The four-seated lifting valves were worked by the well-known Sulzer gear, only the high-pressure trip gear being under the control of the governor. There were two independent air-pumps worked from the crank-pins on either side.

The second engine was a horizontal tandem, with fly-wheel dynamo by I. I. Richter & Co., of Winterthur. The normal load of this engine was 750 indicated or 650 effective horse-power The dimensions of the cylinders were:—High-pressure diameter, 20½ inches; low-pressure, 34½ inches; stroke, 43¼ inches. The revolutions per minute were 100. The power given above was developed with 162 pounds steam, with a cut-off in the high-pressure cylinder of 23 per cent. The valve gear was of the same type as in the large engine, and, generally speaking, the arrangements of the two engines were practically identical.

The other two engines exhibited were a double-tandem vertical and a single-cylinder vertical, both of comparatively small size. It remains only to add that the exhibit of this well-known firm was carried out in a manner worthy of their reputation.

BRITISH INDUSTRIAL WELFARE

THE ERRING POLICY OF THE BRITISH WORKINGMAN

By A. Hamilton Church

THE British workman finds himself to-day in the presence of wide changes and developments in the methods and organisation of production. He is, as a body, strong and well organised, and, therefore, in a position not only to form a corporate opinion, but to give that opinion practical expression. Upon the correctness of his attitude towards these changes depends the welfare not merely of a few individual firms, nor of a few particular trades, but of the entire body politic.

In one sense, the apparent conflict between the interests of employer and employee will never admit of a final and satisfactory solution of the labour problem. It is in the nature of things that the one should cry continually,—"I want more return for the wages I pay. Competition becomes keener day by day." The other as promptly replies,—"The tendency of the times is towards easier life. We must share in that tendency. We want shorter hours, but the same, or higher, wages."

The amount of a day's work cannot be measured in foot-pounds of energy. There is no standard applicable, except the quantity of any particular output. And the overwhelming tendency, far beyond control either of employer or workman, is for the value of output, as measured in labour-hours, to fall. But the absence of any natural standard, any positive connection between a fair day's wage and its outcome in a fair day's work, makes the problem a hardy perennial, surviving all possible changes, and ready to break out amidst the newest of circumstances at a moment's notice.

This must not be considered a discouraging circumstance. It merely indicates that no shibboleth, no convenient, all-resolving formula will ever be found to reconcile, once and for all, the conflicting interests of the two factors in productive work. It means, further, that we must be suspicious of any principle, except mutual respect and fair

dealing, that professes to offer such a solution.

There is also something that it does not, and should not, mean. It does not mean that there is no real mutual interest between employer and workman. On the contrary, nothing is clearer than that their mutual interests are a very much larger item than their mutual differences. Looking at a nation as a whole, we think of what binds it together,—we do not think of the little jealousies and party differences by which its units are divided. So with the industrial section, we see that it is a single or organic whole, with only one life, and that its life is threatened if the smaller antagonisms contained in it become prominent features.

Thus by another route we come to a realisation of the vast importance of the correctness of the British artisan's attitude towards the tendencies of the day. We see that he must distinguish between output and rate of labour,—two things which had a very close relation when every man laboured solely for himself, but the interrelation of which under latter-day conditions has practically vanished. From that day on which intelligence came to the rescue of muscle, output began to be independent of rate of labour.

The workingman must grasp the simple truth that as long as man's daily work does not take him near the limit of physical or mental endurance, the amount of his output is, in reality, a matter of indifference to him in the personal sense. If, physically and mentally, his work is well within his powers; if, in the pecuniary sense, he is well up to the standard of comfort he is used to, any increased productiveness which improved methods have enabled his employer to arrange are so much clear gain, not to him personally, nor very often to his employer personally, but to the national industry in its power of competing successfully in the markets of the world. This truth is surely not so deep nor so vague that it should require much illustration. It may be well, however, to restate it in other terms.

The demand for any article is not a fixed quantity at any one time. The capacity of the world to give orders for steel rails, or locomotives, or even for door-knobs and fire-irons, does not depend upon the desire of this or that person for these articles. It depends upon the intensity of the demand in relation to the market price of the things. A foreign or colonial railway company, for example, thinks of new equipment. Its engines are the worse for wear, need replacing, will not, in fact, do their work as efficiently and economically as new ones would. But the railway company does not, therefore, rush into the market and give orders right and left for new locomotives. Not at all. It has first to consider the market price. Will it do better to wait? Again, shall it inquire in the Belgian, or the American, or the German, or the British market? If, on inquiry, it finds all these markets unfavourable, it will not purchase engines at all. It will simply wait for more favourable times.

But, it will be objected, the order will have to be given out some day. Quite true. But the point is that here, by a single, though typical, instance, has been demonstrated the principle of "elasticity of markets,"—the tendency they have to expand into "orders" under favourable conditions, or to remain in the unsatisfactory stage of simply "inquiries" when conditions are not favourable. The fallacy of the popular idea of there being "so much work in the world" at any one time and no more, follows as an inevitable deduction.

To resume the history of this particular order! The day comes when the railway company hears of a downward tendency in the producing centres. Orders are "slacking off." Shops are getting empty. Directors are walking about with long faces. Overtime is "knocked off." Reductions in the working strength are heard of amongst the men. General gloom sets in. But the railway does not share in this gloom. It smiles broadly, disinters its plans and specifications, and posts them, as before, to Liége and Manchester, Pittsburgh and Essen.

We come here to the question which,

above all others, the British artisan must understand. He knows well enough that the order will go to the manufacturer who can quote the lowest price; for quality here is not in question; that is guarded by the specifications. Who will stand the best chance of getting that order? Will it go to the country where the typical employer is he who pays the lowest wages, who has the least consideration for his men, who looks upon his business as a mill to grind out profits and dividends, and nothing else?

It will not. It will go to that country, and no other, which has organised its business so that it has the largest output for the smallest expenditure. But this does not mean that the smallest rate of wages will be paid there. On the contrary, we have the example of America to show us that a high ratio of output to expenditure is always connected with a high wages-rate. The order will go to that country in which the artisans, as a body, not only "work new methods for all they are worth," but are eager to find out and adopt such methods. It will go to that country in which the artisans do not seek to handicap their employers by trying to make rates of wages independent of output, but base their claims for higher wages and more consideration on the only intelligible, and, in the long run, successful, basis,—higher efficiency in production per working day.

Finally, it will go to that country in which the highest intelligence is displayed by the industrial body, both employer and employee, as a whole, in which the entire industry, in its every member, is animated by a determination to be in the front rank in means and methods, and to allow no conflict of interests, however difficult of adjustment, to stand in the way of "working better methods for all they are worth."

Putting aside the baseless theory of a fixed amount of work existing in the world, what possible and reasonable excuse is there for the artisan to put his own industry at a disadvantage? He puts no more money in his own pocket. On the other hand, by basing his earning powers on something unreal (and what else can that practice be called which insists on two men being employed to do what one alone is fully capable of doing?) he is running a risk of an unpleasant awakening in these days of sensitive markets and swift communication between producer and consumer.

It is easy to say that one man has been displaced by the adoption of a new method. Let us examine this proposition somewhat more closely! It may be a busy time, or a slack time. We will picture both these conditions. If a busy time, with orders rushing into the world's markets beyond the productive capacity to turn them out, then it is clear that the displaced man is not made idle. It simply means that the productive capacity of the world is increased, and that it can better cope with the work. One man does what required two a short time since. Hence, we have a clear addition to the wealth of the world, and to the strength and importance of that particular industry.

With slack times, there is a keen competition for orders. Few workmen understand this part of the industrial process. They frequently, if not generally, fail to grasp the simple truth that employers have to struggle for their orders. It is not a case of simply turning on a tap to enable the employment of workmen, the running of machines, and the making of profits. In these days the arena of the struggle is the whole world. The consumer in South Africa or South America knows quickly where his advantage lies in purchasing. If it be a slack time, he can, at leisure, turn over in his mind the comparative merits of the Belgian, the German, the British, the American, and, in some cases, even the French, producing areas.

But though the times be slack, some one will benefit by an order to be given out. Work will be provided for some artisan, profit for some manufacturer. But which? Will it be that artisan who insists on continuing to give the whole of his time to work which in more enterprising places is done in half that

time? Will it be that employer who has to charge prices to cover unreal services performed by his workmen? Is it not clear that that employer will be out of the race, and that, so far from that artisan benefiting from his peculiar attitude towards modern progress, he will equally be out of the race? Instead of maintaining the ratio of wages to output he intended, there will be, in the case of this particular order, no output, and consequently no wages. The order will go, other things being equal, to that market in which the work can be most cheaply produced. It will be divided amongst those artisans who, by freely entering into the modern spirit of productive organisation, helping and not hampering it, have put their employers into a position to successfully compete in the world's markets.

Neither trades unions, nor employers' federations, nor acts of Parliament can prevent the trade of the world from flowing into the channels wherein it is best served. In the five years ending 1898 the rate of increase in exports from Germany was more than double, and that from the United States more than quadruple the increase in British exports in the same time. Do these figures favour the policy of restriction? Is not every workman, quite as much as every employer, interested in trying to realise their full significance?

That they are not so realised is, however, perfectly plain. A Yorkshire engineer told the writer recently that amongst his employees, there is not only the bitterest antipathy exhibited towards new machines and new processes tending to increase output, but that this attitude is backed up by a selfish cynicism that is the most saddening feature of the situation. "My men say that they will not do anything to increase output. It is nothing to them that business is lost. They tell me openly that when it goes elsewhere they will follow it."

This may be, and probably is, an extreme and exceptional case; but that it is becoming typical, more and more, of the British artisan's attitude cannot be doubted. That, if not combated and dispelled, it will lead to disaster, no less to men than to masters, requires no profound thought. But that it will be in the power of the men, having ruined their trade at home, to follow it abroad, is one of those reckless propositions that can be believed only by those who dare not face the facts.

Where is the British artisan of this type likely to be welcomed? In Germany, or in America? It is possible, but not, by any means, probable. In any case, he can obtain a footing in either country only by abandoning his old policy, his cherished convictions, and by remodelling himself on lines in harmony with his new surroundings. This might, with better grace, have been done at first, without the sharp spur of distress due to closed works and moneyless Friday nights to drive him forward into proper enterprise and activity.

What, too, can be said of another case, typical of another kind of policy, which cannot be regarded as remarkably helpful either to master or man? Some time ago a man started business as an engineer, not in a large way, but on a sound footing. A few months later he put in a new machine, in order to do some particular piece of work. That was the beginning of the end. Over the work done on this unlucky machine a tremendous dispute arose. Not with the employer, be it noted. He was not concerned in it. No one said, or wished to say, a word against his right to put in the machine, or to do that particular work on it. It was simply a dispute between rival trades unions, each claiming the sole right of its members to do the work. One body claimed it because it was part of a certain mechanism; the other claimed the work because it was being executed by a machine process. A strike ensued. It lasted several months. In fact, as far as that particular employer was concerned, it lasted for all time, for the works were soon after closed, and the owner went to the wall.

If the "man can follow the work," then to a far greater extent can those who organise and direct enterprise afford to ignore Great Britain as a field

for that enterprise. They, too, can go abroad, and, what is more, they are going abroad. It is as easy to build a works in Ohio as in Lancashire, and with very little difference, as far as selling facilities on the British market are concerned.

How far is this process of disintegration, due to cross-purposes, to go? Is it unreasonable to ask for, and to expect, a more generous and more enlightened attitude of organised labour towards the industry, as a whole, by which it lives? Will no one undertake a campaign to convert the British artisan to a proper appreciation of the true principles of progress? Millions are spent in the course of a few years in the strife of political parties to decide whether A or B shall occupy a certain office; but the far more vital question of bringing the interests of masters and men to one focus, uniting them in defense of their own industry, permeating them with a desire to increase the efficiency of their powers, mental, physical, and mechanical, so that they may keep to the front, in spite of all opposition and competition, is wholly neglected.

No sensible person will question the usefulness of trades unions. The trades union is the turning point on which British industry has to revolve, but it is an essential and vital matter that it shall not be a turning point of high resistance. In the British engineering trades alone 390,000 working days were lost by strikes in 1899. And, in addition to this, what figure must be put down to the silent and passive hostility of unions and their members towards improvements and economies in productive processes? Such items of loss do not appear in any official returns, but they are none the less formidable.

So far as the effect of machine improvements on the welfare of the workingman is concerned, it may be mentioned that when the machine welding of gun barrels came into operation, and, in its turn, gave rise to the infinitely larger industry of tube making, the workmen engaged on the older hand process lost their work. A similar fate overtook those who made "skelps" for muskets. Instances might be multiplied to any desired extent of similar happenings. It is on these that the militant unionist takes his stand.

The mistake is to contrast an early stage in the evolution of manufacturing industry with the present advanced stage. Fifty years ago, and from that time backwards, hand skill dominated industry. Every improvement destroyed some old trade, some ancient handicraft, learned with laborious training, and commanding exceptional terms in proportion. The hand loom had to go. The hand-wrought man had to go. A hundred separate trades had to go, and were merged in new and wider groupings. How many former separate trades are to be traced within the field of the modern engineer?

What possible improvements can be made to-day that are likely to have similar uprooting and destructive effects? Surely very few. In former days, with their subdivision of crafts, the introduction of the machine meant, perhaps, ruin to the hand craftsman. He had but that one narrow skill, could do nothing else; he was, in fact, himself little better than an old-type machine. To day even the traces of this stage are fast disappearing. Processes take the place of trades.

The tendency of modern improvements is no longer to abolish hand skill, because, in the old sense of the word, there is scarcely any hand skill left. It is, on the contrary, in methods to eliminate the training and cunning of the muscles, and substitute for them the training of the intelligence, that most inventions find their proposed utility. Compare the sweat and dust-covered toiler of a hundred years ago with the lordly engineering mechanic of to-day, calmly superintending his obedient mechanical slaves, and ask whether great good has come out of all these changes or no. To be consistent, the militant unionist should clamour, not for the closing of the floodgates of improvement, but for a return to the glorious days of handicraft, when every man could do one thing only, and little of that.

SOLDERING ALUMINIUM

By Joseph Allison Steinmetz

THAT aluminium can be successfully soldered has latterly been a matter of news to many people, especially in Great Britain and on the European Continent, where soldering trials with the metal have hitherto evidently not given any encouraging degree of satisfaction. In the United States, on the other hand, at least one form of aluminium solder has successfully passed through practical test, and with the revived interest in the matter it has been thought that Mr. Steinmetz's brief contribution to the literature of the subject given below will prove timely, and perhaps suggestive of good.—THE EDITOR.

Prominent among the peculiar characteristics of aluminium, as compared with other common metals, is its physical reluctance to the acceptance of a fusible alloy that will satisfactorily unite its surfaces or margins. Indeed, the lack of a perfect solder has seriously retarded the development and manufacture of articles made from sheet aluminium, when their shape or contour is to be accomplished by the uniting of separate pieces in the evolution of the finished product.

Aluminium is unique among the sheet metals of commerce in this respect, and a casual consideration of its physical properties will be necessary for an understanding of this difficulty. The reasons that aluminium is a refractory metal to solder are entirely physical. It is extremely difficult to expose a bare surface of aluminium to the action of a solder, although the mechanical difficulties of grease and dirt are quickly and easily removed, and need not appear as features in the problem.

Upon attempting, with any ordinary solder, to join sheets of the metal, it is noticeable that the mixture does not take hold, but tends rather to run off, or perhaps it will chill, utterly refusing to tin the sheets, and rarely adhering to the aluminium. The reason of this behaviour is that there is always present a thin, continuous coating of oxide, which effectually prevents the solder from getting to the true metal beneath. This thin, almost invisible, skin of alumina, or oxide of the metal, is of instantaneous formation, and the surface of the metal may be scraped or filed without even temporary relief because of the immediate renewal of the coating.

The uses of fluxes and acids to overcome this difficulty have been repeatedly suggested, without securing satisfactory results, and a new theory tending toward the solution of the problem must needs be approved. Dr. Joseph W. Richards, of Lehigh University, Bethlehem, Pa., U. S. A., conceived the successful practice of overcoming the difficulty, by incorporating into the composition of the solder an ingredient that would remove the oxide film during the process of soldering, thereby preserving the surfaces clean until the union of the parts had been accomplished. The solder devised and patented by Dr. Richards carries in its make-up an alloyed flux of phosphorus in tin, the theoretical necessity of the simultaneous action of the flux and the taking hold by the solder being confirmed during many years by the satisfactory results obtained in actual commercial practice.

The high heat conductivity of aluminium is another characteristic of this strange metal, and the refusal of many solders to perform their expected duty is traceable to it. The aluminium quickly and readily absorbs the heat from the soldering iron, and the temperature of the tool is thus so far reduced that the solder "freezes" at the

joint and failure ensues. To overcome this difficulty, which arises in large work particularly, it is necessary to keep the soldering iron very hot, and oftentimes it tends to the betterment of the result to apply heat likewise to the parts to be joined.

Aluminium is a highly electro-negative metal, and it is this property that, in addition to causing the instantaneous formation of the thin skin of oxide already mentioned, tends to operate in another way, quite as disastrous, by setting up a galvanic action at the joint, between the solder and the aluminium, inducing failure through rapid disintegration. Therefore, in devising a solder, it is plain that it should be composed of those metals nearest to aluminium in the galvanic series in order to reduce this disintegrating action to a minimum. Accordingly, zinc suggests itself as an excellent base.

Almost any one can solder aluminium by such simple means as using pure zinc, or pure tin, or both in combination, and joints of accuracy and strength have been thus obtained. Upon these results, which are at best but temporary, yielding soon to the disintegrating influences above noted, have rested the reputations of many of the so-called aluminium solders of commerce.

It is not the purpose of these few remarks to schedule the proportions of the various metals in the many alloys offered on the market under the name of solders, but rather to show, in a general way, the reasons of their repeated failures, and to suggest lines of thought and experimental work most likely to be productive of sensible results. To be a commercial success, any solder must conform to the following requirements:—It must take hold easily upon the aluminium; it must be conveniently handled without complicated tools or sundry fluxes; it should melt readily; it must be strong, malleable, and tough; it must not combine elements inviting disintegration; it should be of the same colour as aluminium, and it should not tarnish with age. To all of these conditions Dr. Richards' solder conforms.

Current Topics

In connection with the matter of machinery foundations and vibrations resulting from their insufficiency, there comes to mind the apt remark made by some one concerning a certain steam hammer that it seemed to him much like an earthquake on stilts. Steam hammer foundations have, indeed, proved difficult things to deal with in many instances, owing to the particularly trying conditions involved in the operation of such a piece of apparatus.

In erecting the 125-ton steam hammer of the Bethlehem Steel Company a number of years ago,—the largest hammer in the world, by the way,—a foundation about 60 feet square was prepared, and piles were closely driven over the whole area. The piles were covered over with timbers 34 inches square, and on top of these were put steel beams about 35 feet long, and each weighing something like 40 tons. On top of these there was more cross-timbering, and then the anvil block was put on, weighing about 1500 tons. After running the hammer for a short time the foundation went down 8 or 10 inches, and, unfortunately, did not go level, which made matters worse. Mr. John Fritz, under whose supervision the work was done, in speaking of it some time ago, said that he thereupon took out everything down to the piles, levelled the foundation up again, and put in a 2-foot thickness of wood shavings. A lot of men were put on to tramp that down to about 16 or 18 inches; the heavy timbers were then placed on the shavings; next came the steel beams, placed crosswise, and on top of these 10-inch square timbers. After these came about fifteen hundredweight of cast iron, covered with 3-inch plank and 12 inches of cork. On top of the cork there were, again, 10 inches of timber, and then finally came the anvil block. The elastic shavings bed was intended to absorb the heavy blow on the foundation, and subsequent experience showed that it admirably accomplished its purpose.

Among the many applications that have been made of electric power to the driving of machinery there is one distinctly novel in the gymnasium outfit aboard the new cruising yacht *Prinzessin Victoria Luise*, of the Hamburg-American Line. A gymnasium itself is an unusual enough institution aboard ship, and in this particular instance the equipment comprises the latest forms of Dr. Zander's system of apparatus. One of the appliances affords all the varieties of horseback exercise, a conventional saddle, stirrups, and other accessories being provided, and, with them, suitable adjusting mechanism, so that the whole outfit can be given more or less violent vertical and slightly horizontal reciprocating movement through a system of cams and connecting-rods, simulating very closely the motions of the animal in life. Another apparatus is a form of couch, moving back and forth over a set of rubber-tired wheels, so placed as to gently massage the back of the person reclining upon it. More violent massage of other parts of the body is obtainable in several additional machines,—one a so-called vibrator, which, on trial, is found to admirably justify the choice of name. To the engineer, however, the principally interesting feature about them all is found in the fact that the actuating mechanism of each is a small electric motor. The flexibility of the electric drive system is here almost indispensable, and has been utilised to full extent. Without it some possibly unsightly, and certainly awkward, shafting transmission would have been compulsory, and might have been a prohibitive factor in planning the installation.

In the opinion of Mr. Geo. W. Dickie, the general manager of the Union Iron Works, of San Francisco, the whole modern method of testing and inspecting materials is founded on the belief that the faculty of judgment in an inspector is a dangerous thing, and that all excuse for its cultivation must be eliminated from his mental stock in trade. In a recent paper before the Technical Society of the Pacific Coast, Mr. Dickie states that at one time he saw condemned and broken up a large bronze casting that had cost about $3000, because the coupons or test pieces showed less tensile strength than the specifications required. The casting itself was perfectly sound and very tough; in fact, admirably suited for the purpose for which it was made, and not the slightest doubt of its character was expressed by any one who saw it. Yet, because the test piece was required to

show 55,000 pounds tensile strength per sectional inch, and broke at 44,000 pounds, a great deal of labour and costly material was deliberately destroyed, the inspector claiming that he had no discretion, which means no judgment, to exercise; and when the case was appealed to a higher authority, that authority, who could not see this good piece of work, entirely suited for its place in the structure and with ample margin of strength, simply sent it to destruction, with the careless remark, written officially from the other side of the country, that the requirements of the specifications must be fulfilled.

Mr. Dickie did not intend to imply that physical tests are not very important in deciding the quality of material, but that when applied without judgment they may result in great waste of both labour and material, for they do not present the whole case, even as to the character of the material of which the test pieces themselves are made. "We often have plates of steel," Mr. Dickie further remarked, "where the test pieces, cut directly from the plate, will give fine results, say, 60,000 pounds tensile strength and elongation of 30 per cent. in 8 inches, and will double over on themselves without sign of fracture, and yet the plate itself would break like glass in bending over a large radius. I have cut test pieces right out of plates that would not bend at all, and the test pieces would double over on themselves without sign of fracture. Not long ago I had a plate of government material to bend on the press for a keel plate, but the plate broke hopelessly in bending. There was no other plate to replace it of material that had been tested and accepted for government use, and the inspector would not allow any other plate to be taken for the purpose. I, however, took a plate of steel for merchant work and bent it to the required form with no sign of fracture. We cut a test piece out of the broken plate, right by the fracture, and it showed 61,000 pounds tensile strength and 28 per cent. elongation, and bent over on itself without fracture. Then we took a test piece out of the plate that had been successfully bent to the desired form and showed 62,000 pounds tensile strength and 22 per cent. elongation, and it broke before it had completely bent over on itself. Therefore, the perfectly bent plate was not allowed to be used because the test piece did not meet requirements. Here the test, intended to guard against the use of unsuited material, resulted in preventing the use of eminently suitable material; not because of anything wrong in the test, but through the lack of judgment in applying the result of the test to the desired end"

Less than one pound of coal per indicated horse-power per hour,—to be exact, 0.97 pound,—is recorded by *Engineering* for the new steamships, *Inchdune* and *Inchmarlo*, on voyages between Hartlepool and Dover. These ships have Mudd's five-crank engines and a boiler pressure of 267 pounds, generated in two single-ended boilers, with Ellis and Eaves' system of induced draught. Fitted in the uptake, immediately above the level of the highest row of tubes, is a superheater, consisting of a series of wavy tubes through which the steam passes on its way from the boiler to the engine. The steam enters at the top, where the gases are comparatively cool, and passes out of the main steam pipe at the lower end, where the gases are hottest. A temperature of from 460 to 480 degrees Fahr. is obtained. Above the superheater come the air-heating tubes and casings, which, together with the fans, constitute the induced-draught system. The engines have five cylinders, of diameters, respectively, of 17 inches, 24 inches, 34 inches, 42 inches, and 42 inches by 42 inches stroke, the high-pressure valve being of the piston type, and the others flat valves.

A line of passenger railway only six miles in length, and yet making use of

three different modes of traction in that short distance, seems something rather unusual. Yet such a line was opened about seventy years ago, and constituted the first railway in the South of England upon which steam power was employed, or which was specially authorised to carry passengers, if any should be found bold enough to risk their lives in so foolhardy a manner. The line in question, the Canterbury and Whitstable, was designed, as told in *The Engineer*, of London, to connect the Kentish capital with its nearest seaport, and the country between, rising to a moderate elevation, it was decided that stationary engines and ropes could alone do the work on the steepest gradients. To get over the first section out of Canterbury, which rose 1 in 46 for 3300 yards, a 25 horse-power engine was erected at Tyler's Hill. There was a tunnel on this part of the line, half a mile long, 12 feet high, and the same in width. From Tyler's Hill the rise continued, but at the easy rate of 1 in 750 for 1980 yards further, till it reached the summit at Clow's Wood. Horses were used on this section, but a fall of one mile at 1 in 31 towards Whitstable necessitated a second engine, also of 25 horse-power, at the bank top. From the bottom of this steep incline stretched a nearly level plane of one and one-quarter miles, upon which the company's solitary locomotive exhibited its somewhat limited powers. A third engine stood at the end of the level, at a place called Church street, and was of only 15 horse-power. It worked a section falling 1 in 53 for half a mile, horses being again used in the remaining 440 yards, which brought the railway into Whitstable. The harbour there was improved and extended by the railway company, which had power to charge each person landing on, or embarking from, its wharf the sum of 1s. Goods could be charged up to 1d. per cwt. The railway rates allowed were very high, whilst 1s. per ton extra might be charged for the use of each incline. Whether the maximum charges were always levied is probably doubtful. The line was formally opened on May 3, 1830, with the usual accompaniments of bands of music and extensive feasting and health drinking. Public traffic began next day. For many years the old line was regarded as a great curiosity in that part of the country, and it certainly seems to have deserved its reputation.

A NOT unworthy counterpart of the above-mentioned railway is a seven-mile

AN OLD JAPANESE TRAM CAR

interurban line in Japan, connecting the two coast towns of Atami and Yoshihoma, in the province of Izie. The annexed little sketch of one of the cars used on it appeared recently in the *Street Railway Review*. The line is operated by man power. The train crew, if it may be so termed, comprises two men and a boy. The men, muscular coolies, push the car on the upgrades, and jump on the rear platform for a ride when the car is coasting on a

level or down-grade. The boy rides on the front platform, blows a horn as a warning at hills and curves, and operates the brake.

THE steps which have led to our present knowledge of the manifestations of electricity can be quickly told. According to Professor John Trowbridge, in a review of the progress of electricity during the century just closed, given in the New York *Evening Post*, the first step was taken by Galvani, who, just before the preceding century dawned, demonstrated that electricity could be produced by the contact of metals with fluids. His experiments suggested to Volta, in 1800, the electric battery. Here was a means by which an electric current could be produced; and Oersted with this current showed a connection between electricity and magnetism. The current, in passing through a wire near a compass-needle, could change the reading of the needle, and the changes depended upon the direction in which the current flowed. There seemed to be a suspension and a hush between each of the turning points in the history of the advance of electricity, which are typified by the stillness before a thunderstorm. Oersted's discovery was made about twenty years after Volta constructed his battery. It was more than ten years after Oersted that Joseph Henry and Michael Faraday discovered another relationship between electricity and magnetism, which involved the possibility of producing currents of electricity by the motion of a magnet. This discovery was the converse of Oersted's; the series of phenomena which it revealed embrace the subject of electromagnetism, and have led directly to the invention of the dynamo and electric motor. The world, however, did not realise in 1831 the importance of the steps taken by Henry and Faraday. Another ten years elapsed before the electric telegraph became a success. Then in 1861,—thirty years from the date of the discovery of electromagnetism,—Paccinnoti invented the armature, which Gramme improved, and we had the dynamo and the electric motor. Again, in a little more than ten years, the telephone came, and the mechanical engineers and the mechanic, thoroughly aroused to the possibilities in the practical employment of electricity, took hold with astonishing energy.

WHEN Tyndall came to America in 1870 to deliver lectures on light and electricity, he brought with him one hundred Grove cells to produce an electric light for the purposes of demonstration. His assistant was obliged to spend two hours before each lecture in arranging these cells, filling them with acids and scraping the connections, retiring from each encounter almost asphyxiated by the irritating and poisonous fumes of nitrous oxide gas. At the present time no lecturer on science in the halls where Tyndall spoke need spend a moment in providing a source of electricity. It is on tap, so to speak, and can be obtained by touching a button. Tyndall, in his highest flight of scientific imagination, did not picture a development of electricity which would light the halls in which he spoke, which would convey him to and fro with great speed through the streets which he used in going to them, and would enable him to whisper from one city to another, across a thousand miles of intervening space.

THE chief source of electricity, Professor Trowbridge continues, is coal, and the century just closed gives no hint of a possible rival to coal, unless we except water power. There promises to be a great development in the use of waterfalls in places remote from tidewater, wherever the transportation of coal adds greatly to its cost. Thus, in Switzerland, water power from the numerous mountain sources supplies both light and electrical power for varied industries. The great plant at Niagara Falls for the transmission of power is watched with interest, for if electrical power can be economically transmitted

from the falls to New York City, the calculations in regard to the diminishing coal supply of the world would lose their ominous character,—unless the geologist can show that the world is gradually drying up. The electrical transmission of power has led to a centralisation of steam power in great cities. The small steam engines which were scattered about in numerous workshops have greatly diminished in number, and their places have been taken by electric motors supplied with current from a central station. In the same way gas engines, which at one time seemed to be rising in importance, have largely given way to the electric motor. Thus the plans to pipe gas from central gas manufactories to all parts of a city for power is checked by the extension of a more subtle medium, far more flexible in its applications. No one will use a gas engine if he can obtain an electric motor, for the care and repairs on a gas engine are far more burdensome than in the case of its rival. Moreover, electrical power can be obtained or shut off by merely moving a switch or touching a button. The centralisation of power in the physical world seems to be a counterpart of that taking place in the commercial world.

C. P. EUGÈNE SCHNEIDER

THE HEAD OF THE FAMOUS CREUSOT WORKS IN FRANCE

By G. K. Lemmy

THE real founder, as he may be termed, of the present Creusot Works, the largest industrial establishment in France, Mr. J Eugène Schneider, the grandfather of the present owner, purchased the plant in 1836. At that time it was a comparatively small one, and though both French and British capital and energy had been devoted to it for years past in order to make it a successful and paying venture, all efforts up to that time had resulted in absolute failure. It may be mentioned here that the British firm of Manby & Wilson were interested in the works in 1823, but they also failed. There are still at Creusot an old, square, brick chimney and the remains of an old coal pit, styled the "Manby pit."

When J. Eugène Schneider purchased the works, in 1836, as they then stood, the place counted only 2700 inhabitants; to-day there are 32,000, who all depend upon the works for their living. J. E. Schneider, a man of indomitable energy, started the works on a new footing, laid down a new equipment, the best that could be obtained at the time, and put his whole soul into the task, working night and day, and keeping himself fully alive to the demands that were gradually being made on industrial enterprise. He pulled down, transformed, and improved his plant year after year, so that it should ever be ready to meet the increasing requirements. In short, he laid, on business lines, the foundations of one of the largest and most comprehensive industrial establishments in the world. He was not going to fail, like his predecessors, not he, and his memory is still revered in the whole district, and justly so, for he made it the richest for miles around.

M. Schneider died in 1875, and his son, Henri, who succeeded him, died in 1898. Since 1898 Mr. C. P. Eugène Schneider, his son, and grandson of the founder of the works, has been the responsible owner of the concern. He is, if one may be allowed to use a current expression, "a chip of the old block,"—a capable and genial master.

The present appellation of "Creusot Works" has become somewhat errone-

ous, owing to the fact that Messrs. Schneider, while enlarging the establishment year after year, put down or purchased works in several other French towns. A remarkable feature is the interest which always has been taken in the welfare of the men by the Schneider family. It is a difficult undertaking, and sometimes a most ungrateful one, for a works owner to be both master of his men and, in a sense, their father. But Messrs. Schneider have always succeeded in their philanthropic as well as in their business undertakings, apart from two recent disturbances, fostered by professional agitators. But these were amicably settled by Mr. Schneider's intervention.

It is not necessary to spend much time among workmen to find out that whatever is granted them freely, as a gift, for their well-being, is very soon considered by them as a thing absolutely due to them. This is most discouraging to those who give, and the fact that Messrs. Schneider and their family have continued their grants, through thick and thin, in bad as well as in good years, and in full justice to every one concerned, notwithstanding several manifestations of discontent, is a proof, if any were needed, that they take to heart the happiness of all who serve them in whatever way, whatever be their creed. These grants cost Messrs. Schneider & Co. and Mr. Schneider's private purse a total of from £80,000 to £90,000 every year.

They receive in trust the savings of their men, and act, in this respect, as their men's bankers; they sell to their men, at reduced rates, the necessary land for building purposes, and advance to them, when required, and on liberal terms, the funds for the building; they pay the required capital for insuring to each of their men an old age pension, and Mr. Schneider has recently raised the minimum pension to tenpence a day. They pay subsidies to local charity boards for helping the sick and needy in their homes; they have put down two special homes for old men and women; they supply each employee with coal free all the year round; a free hospital and free medical and pharmaceutical services are at the disposal of every member of the staff, labourer, workman, or clerk; and they have established free schools in which a first-class education, including English and German, is given. Thus they have for years prepared the rising generations for berths in the shops and in offices of the various works, and also for the higher French technical schools.

As already mentioned, the works and the interests of the firm are now not confined simply to Creusot, which place, by the way, is situated about half-way between Dijon and Lyons, on a branch line from Chagny to Nevers, but are scattered all over France. They comprise coal and iron mines, firebrick works, blast furnaces, coke ovens, steel works, armour plate works, electrical construction works, ship and bridge building yards, gun shops, and proving grounds. One of these is five miles in length, for long-range testing of guns and shells.

Messrs. Schneider have made a speciality of all industrial and metallurgical work. They were the first to build locomotives in France, as far back as 1838, and in 1866 they supplied locomotives to the Great Eastern Railway, of England. It is they who started the manufacture of all-steel and nickel-steel armour plates. Their bridges, rails, locomotives, and marine engines are to be found all over the world. So are their guns, and these have been very much to the front lately, as we all know. It was the Schneider establishment that supplied the Boers with their "Long Toms" and field guns previous to the South African War.

Such is the firm of which Mr. C. P. E. Schneider is the heart and soul, and this brief record more fitly stamps the man than would be possible by anything further that the writer might say.

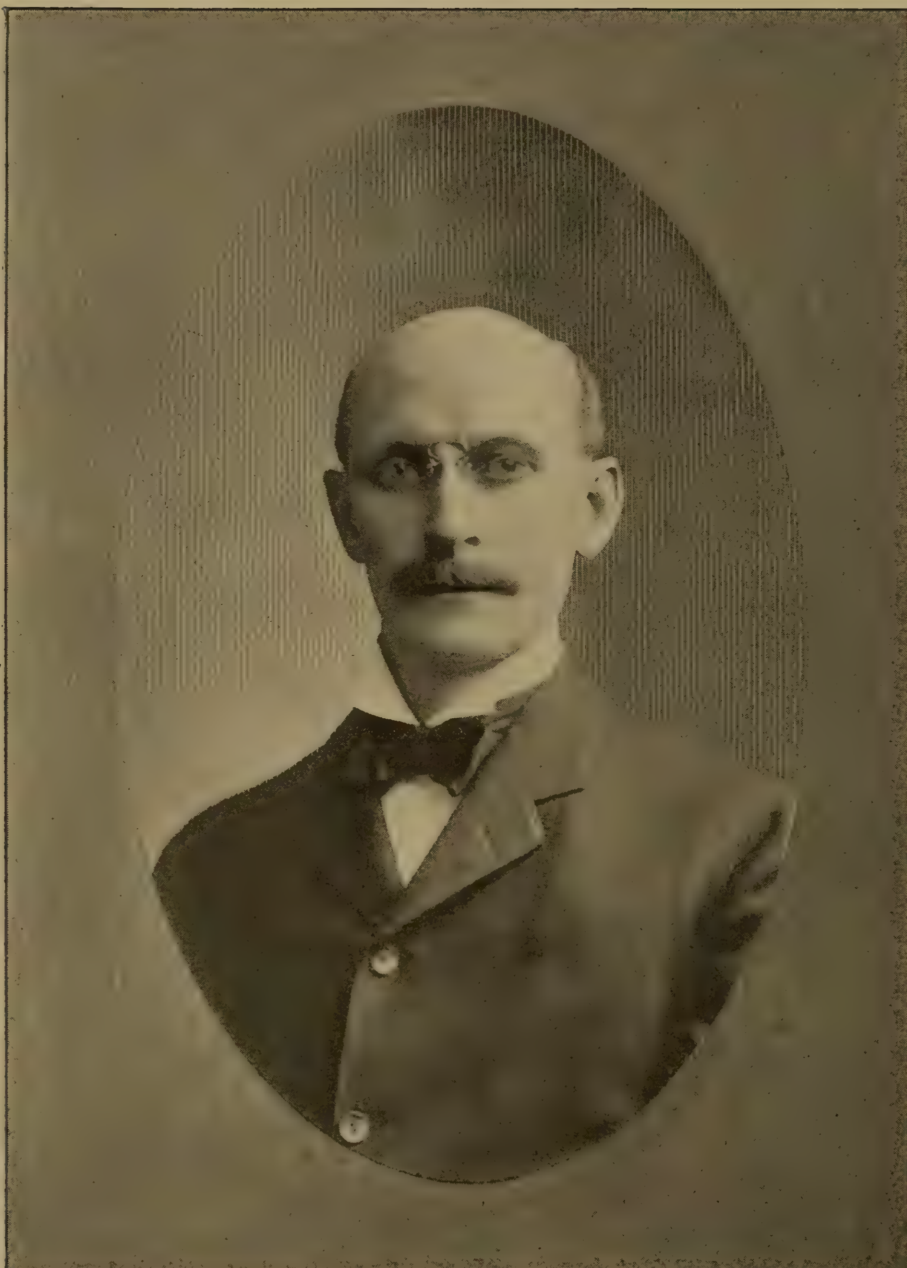


PHOTO BY RICHARD, PITTSBURGH

James Gayley

MANAGING DIRECTOR OF THE CARNEGIE STEEL COMPANY, LTD., PITTSBURGH

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CASSIER'S MAGAZINE

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THE RUSSIAN VOLUNTEER FLEET

By a Staff Correspondent

IN view of the present activity of the powers in China and the possibility of further complications in the Far East, and in connection also with the recent transport arrangements of the British Admiralty for the conveyance of troops to South Africa, interest is attached to the Russian volunteer fleet which has played no small, if inconspicuous, part in the recent stirring events that have taken place on the Pacific border of the Celestial Empire. During that Eastern crisis the steamers of the volunteer fleet were actively employed in the transport of Russian troops to China, as well as the shipment of vast quantities of war material, commissariat stores, etc. One or two of the faster vessels were even equipped with their full armament, in anticipation of possible attacks from Chinese warships.

During the late Russo-Turkish war Russia had an insignificant navy, and entirely lacked cruisers worthy of the name in the modern acceptation of the term. Towards the close of that sanguinary struggle, when complications with several of the powers seemed imminent, the above fact became obvious to all, a great wave of patriotic enthusiasm swept through the land, and a movement was placed on foot by certain Russians, anxious for their country's welfare, for the fitting out of a few ships to act as commerce destroyers in the event of a naval war. The idea met with general support, and committees all over the empire, with their headquarters at Moscow, started a national subscription, which in a few months amounted to about two million roubles. A special commission of naval officers was afterwards sent to Hamburg to purchase four steamers belonging to the North German Lloyd. These vessels were of the best types of their day. Fortunately, however, peace with Tur-

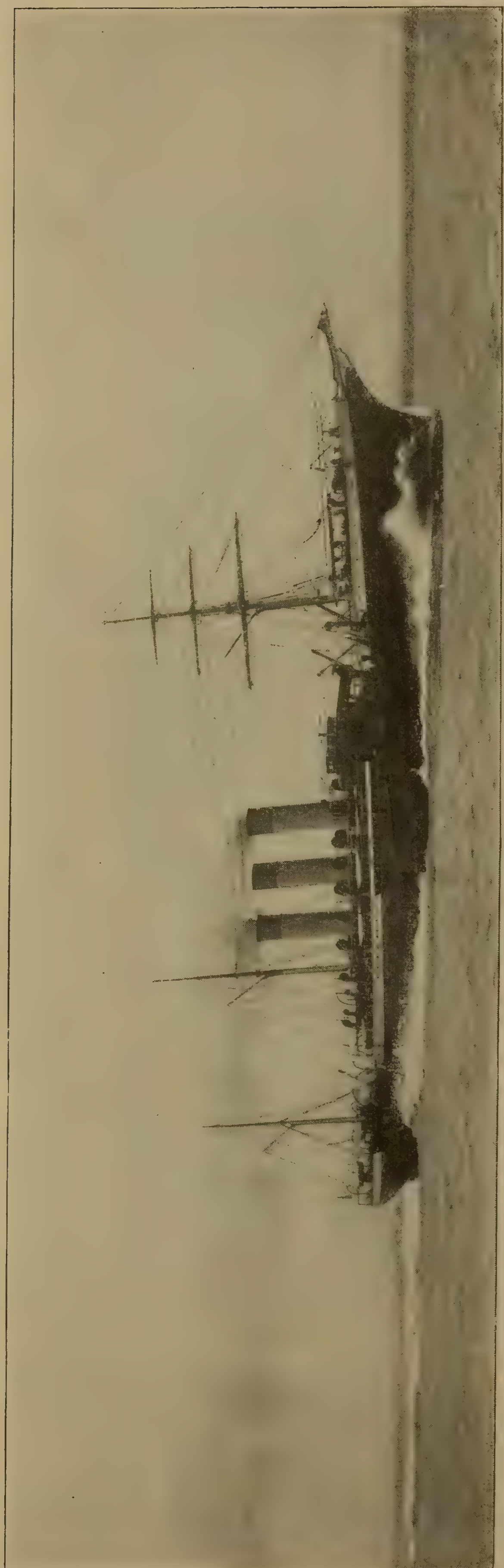


PHOTO BY W. PARRY, SOUTH SHIELDS

THE "KHERSON" GOING AT 20 KNOTS. BUILT BY MESSRS. R. & W. HAWTHORN, LESLIE & CO., LTD., NEWCASTLE-ON-TYNE

key was soon concluded without any further embroilment, so that the newly-born volunteer fleet did not have occasion to try its mettle in actual warfare. But it accomplished very useful work in carrying wounded and sick and transporting troops from San Stefano to the Black Sea ports.

That task completed, the steamers opened a regular line of service between Odessa and Vladivostock, the chief port of Russia's Far East, until recently regarded as the future Pacific terminus of the Trans-Siberian Railway. They were to pursue their peaceful vocation of merchantmen as long as peace reigned, devoting their profits to the construction of new steamers, there being no one to receive dividends, and were to be taken in hand by the admiralty and utilised as cruisers, or transports, in the event of hostilities.

At first the success of the volunteer fleet as a self-supporting commercial enterprise was not brilliant, and at one time the very existence of that useful auxiliary force was threatened; but, fortunately for Russia, the contemplated transfer of these steamers to the Russian Steam Navigation Company was abandoned, and certain reforms in the organisation and financial department of the volunteer fleet were adopted. Partly in consequence of the latter, and to great extent because of the energetic development of the Russian Far East of late years and the construction of the Siberian Railway, which provided abundant freight and a large number of passengers, mainly soldiers and emigrants, an era of prosperity dawned upon the fleet, and this has been maintained ever since. Its record is also singularly free from grave accidents involving loss of human life, and this is all the more striking, as during its existence of nearly a quarter of a century three wrecks

took place,—two in the China seas which are the most dangerous to navigation, and one off the Somali coast of East Africa.

Placed under the supreme direction of the Minister of the Marine, the management of the volunteer fleet is intrusted to a committee presided over by an admiral, of representatives of the Ministers of Finance, the War Office, the Imperial Navy, and the State Audit, which is analogous to the board of directors of an ordinary steamship company. The general management and executive devolve upon the inspector, who is required to be a naval officer. The commanders of the fleet's vessels are also all drawn from the Imperial Navy.

The chief port from which the steamers start is Odessa, although occasionally they make St. Petersburg their point of departure. They pass through the Suez Canal, calling, on their way, at Port Said, Perim or Aden, Colombo, Singapore, and Nagasaki, accomplishing the voyage to Vladivostock in about forty days. At Odessa the fleet possesses excellent repair shops, fitted with modern plant, and all but the more important repairs are made there. The Asiatic terminal port is Vladivostock, the steamers finding it possible to enter the harbour even in winter, when the sea is frozen over with ice more than 12 inches thick, a powerful ice-breaking steamer being provided for the clearing of a channel.

EMBARKATION OF RUSSIAN SHARPSHOOTERS FOR CHINA ON BOARD THE "MOSKVA" AT ODESSA

The fleet of to-day consists entirely of modern vessels, all of them of British build, the original vessels having long ago been eliminated from its list, some wrecked, others sold as obsolete. The steamers are fifteen in number, viz.:—the *Moskva*, *Kherson*, *Petersburg*, *Orel*, *Saratov*, *Vladimir*, *Voronej*, *Kiev*, *Ekaterinoslav*, *Tambov*, *Yaroslavl*, *Kostroma*, *Nijni-Novgorod*, *Kasan*, and *Khabarovsk*, named after the Russian provinces which subscribed to the orig-

THE "VORONEJ," SISTER SHIP OF THE "KIEV," IN DARTMOUTH HARBOUR, WHERE SHE PUT IN FOR REPAIRS AFTER A SLIGHT COLLISION IN THE ENGLISH CHANNEL. SHE WAS TRANSPORTING TROOPS TO VLADIVOSTOCK AND IT WAS ON THIS OCCASION, ABOUT TWO YEARS AGO, THAT DARTMOUTH WITNESSED THE UNIQUE SPECTACLE OF RUSSIAN SOLDIERS EXERCISING ON BRITISH TERRITORY. THE OFFICER COMMANDING THE BATTALION OBTAINED PERMISSION FROM THE LOCAL AUTHORITIES TO LAND HIS MEN—WITHOUT ARMS—FOR DRILL AND EXERCISE

inal fund. They carry each from 3000 to 5000 tons of cargo, and are of two classes,—fast cruisers and less swift transports. To the former belong the first five, with a speed of 19 to 20 knots, while the remainder have a speed of 13 knots. With two exceptions, all of the boats are twin-screw vessels. At the time of writing, a sixth fast cruiser-merchantman, the *Smolensk*, is under construction on the Tyne, to be finished next summer. In each successive steamer built are embodied all the latest improvements and appliances of marine architecture, both in hull and in engines and fittings. As an instance of this, it may be mentioned that the volunteer fleet was one of the pioneers in the Belleville water-tube boiler movement, which has been the subject of so much heated controversy, the 10,000-ton and 13,000 horse-power cruiser *Kherson* being the first commercial vessel of her size and speed to be fitted with these much-discussed steam generators. In fact, the results of that experiment were awaited, and afterwards commented upon, with great interest in engineering circles. Since that first trial the fast cruisers of the volunteer fleet built subsequently were fitted with the same type of boiler.

A brief description of the two types of vessels will not be out of place. As a representative of the auxiliary cruiser type, we shall take for description the *Kherson*, built by Messrs. R. & W. Hawthorn, Leslie & Co., Ltd., of Newcastle-on-Tyne. The *Kherson* is a steel twin-screw, square-topsail, three-masted, schooner-rigged steamship of the three-deck class, 493 feet long over all, and 455 feet between perpendiculars. Of graceful lines, her beam is 54 feet and her depth 37 feet, and when loaded to 24 feet draught, she displaces about 10,675 tons. Her bunkers take 1440 tons of coal, and she can steam 5462 nautical miles at a speed of 10 knots without recoaling.

THE "SMOLENSK," BUILT BY MESSRS. R. & W. HAWTHORN, LESLIE & CO., LTD., NEWCASTLE-ON-TYNE

Intended for the carrying of passengers, emigrants, and cargo, she can also be fitted out at very short notice as a troop-ship. The hull is specially strengthened in order to take the guns which the *Kherson* is designed to carry in time of war. Her armament will consist of three 4.7-inch quick-firers, twelve 75-millimétre, and eight 47-millimétre guns. Provision is made for the shipping of magazines.

The *Kherson* has accommodation for 74 first-class passengers, 46 third-class passengers, and 1484 emigrants. The main saloon is 48 feet long, and above it is a music room about 28 feet long.

PHOTO BY W. PARRY

THE "OREL," LENGTH, 452 FEET; BEAM, 48 FEET; DISPLACEMENT, 8,175 TONS. BUILT IN 1890 BY MESSRS. R. & W. HAWTHORN, LESLIE & CO., LTD., NEWCASTLE-ON-TYNE

THE CONVICT SHIP "YAROSLAVL," LENGTH, 415 FEET; BEAM, 45 FEET; DISPLACEMENT, 8,950 TONS. BUILT BY MESSRS. DENNY & BROS., LTD., DUMBARTON

The tasteful decorations are in light tints, and the paneling is delicately ornamented with artistic poker-work. The upholstery is green leather in the main saloon and antique plush in the music room. The smoking room, too, is attractively fitted up, and is of liberal dimensions. The saloon passengers' cabins are on the main deck, forward of the engines. Every conceivable convenience for a comfortable voyage has been the subject of the designers' careful thought.

The third-class passengers (second-cabin passengers are not carried) are practically emigrants of a somewhat superior kind in regard to the accommodation they receive. They are berthed about twelve to twenty in a cabin, and their necessities are well sup-

plied. The accommodation of the emigrants, whose berths are located on the main and lower decks, is good, and, in regard to fittings and sanitary accommodation, excellent. There are two hospitals on the upper deck, for twenty men and sixteen women, respectively.

The *Moskva* is slightly larger and faster than the *Kherson*, embodying further improvements and more powerful machinery. The *Smolensk*, now in course of construction, is to be provided with quite a new system of engines, which will, when full power is not required, enable her to steam at an economical speed of 12 to 14 knots, with great saving of fuel. The projected armament for that latest addition to the fleet is practically the same as that of the *Kherson*. The *Petersburg*, *Saratov*, and *Orel* are slightly smaller. Their main features, however, are identical with those of the above-mentioned ships.

The transports also are built in accordance with Lloyd's highest standards,—in some particulars even in excess of the latter. They are slower, being engined for economical steaming at 12½ to 13 knots. Although primarily cargo boats, they carry a certain number of saloon passengers, and have provision for the transport of troops or emigrants. The *Kasan*, *Vladimir*, *Ekaterinoslav*, *Varonej*, and *Kiev* average 10,750 tons displacement at full draught, and carry approximately 5500 tons of freight, or about 1000 emigrants on one of the twin decks. For short voyages these steamers can carry, on both decks and in their holds, nearly 2500 men. They are about 450 feet long, 50 feet beam, and 32 feet deep. The passengers' accommodation is of a somewhat less pretentious kind than that of the faster boats. The *Nijni-Novgorod*, the oldest representative of the fleet, is also the slowest, steaming 10½ knots only. The *Tambov*, *Kostroma*, and *Yaroslavl* are substantially the same as their larger sisters, but of less displacement (9000 tons).

Special interest is attached to the *Yaroslavl*, as this vessel is fitted up as a convict ship. She is employed in the transport of the worst class of sentenced criminals (mostly for murder) to the island of Sachalin, or Saghalien, situated to the north of Vladivostock. As she often takes from 700 to 800 convicts on board at a time, special arrangements have been made to insure their safe custody. The main and lower decks are subdivided into a number of

THE "KIEV," LENGTH, 446 FEET; BEAM, 49 FEET 6 INCHES; DISPLACEMENT, 10,850 TONS. BUILT IN 1896 BY THOMPSON, CLYDE BANK

PHOTO BY W. PARRY

THE "PETERSBURG," LENGTH, 462 FEET; BEAM, 52 FEET; DISPLACEMENT, 9,460 TONS. BUILT BY MESSRS. R. & W. HAWTHORN, LESLIE & CO., LTD., NEWCASTLE-ON-TYNE

THE "MOSKVA." BUILT BY MESSRS. JOHN BROWN & CO., LTD., CLYDE-BANK. LENGTH, 508 FEET; BEAM, 58 FEET; DISPLACEMENT, 12,000 TONS.

THE "KAZAN," THE LATEST ADDITION TO THE FLEET, PURCHASED BY THE RUSSIAN GOVERNMENT DURING THE CHINESE CRISIS LAST SUMMER AS A TROOP SHIP, AND SUBSEQUENTLY HANDED OVER TO THE VOLUNTEER FLEET. THE "KAZAN" IS SHOWN IN THE HARBOUR OF NOVOROSSISK ON THE BLACK SEA

compartments by means of steel bars; between these partitions, running lengthwise, are passages of ample width for the sentries. As the entire military escort does not exceed 70 officers and men, special provision has been made for the quelling of possible mutiny among the unwilling passengers carried. Fortunately, so far, recourse to extreme measures has never been made, although once or twice plots were hatched for the seizing of the ship; but on each occasion they were discovered in time to avert anything serious.

Special attention has been paid to the efficient ventilation of the *Yaroslavl*, and a liberal supply of fresh air is insured to the convicts by means of electrically-driven fans. But for their confinement, the exiles fare as well as the ordinary emigrants; during the passage through the tropical seas their fetters are removed and batches of them allowed on deck, in turn, for a refreshing *douche* of sea water from the ship's hose. Parties of convicts are permitted, as a special favour, to participate in the ship's work, such as the cleaning of the metal fittings, washing of decks, etc., and they much appreciate this privilege, which breaks the monotony of their enforced idleness on board. When the *Yaroslavl* is used as a "trooper," all signs of her penal character are removed from sight.

The smallest representative of the fleet proper is the *Khabarovsk*,—a steel,

square-topsail, two-masted, schooner-rigged steamer of 2760 tons and 14 feet draught. She is employed on local service in the territorial waters of the Russian Far East, and keeps up communication between Vladivostock, Kamchatka, Sachalin, Port Arthur, etc.

The fleet receives an annual subsidy of 600,000 roubles, on condition of a specified number of new vessels being constructed before 1902, and the fees paid for the passage of the Suez Canal are refunded by the State Audit. In addition, in 1896 an extraordinary grant of money was made by the government, on very favourable terms, to enable the building for the fleet of three large cargo transports, the steamships *Kiev*, *Ekaterinoslav*, and *Voronej*, outside the original programme, in view of the enormous export of railway material from Russia to her Eastern possessions for the construction of the Manchurian line. Without these vessels the freights would have helped to swell the dividends of foreign shipowners, the Russian mercantile marine being too insignificant to cope with the great increase of traffic.

In conclusion, the writer desires to express thanks to the shipbuilding firms of Messrs. William Denny & Brothers, Ltd., of Dumbarton; Messrs. John Brown & Co., Ltd., of Clyde-Bank, and Messrs. R. & W. Hawthorn, Leslie & Co., Ltd., of Newcastle-on-Tyne, through whose courtesy it has been possible to present the majority of the illustrations accompanying this article.

AMERICAN SOFT COAL

SOME REASONS FOR ITS GROWING EXPORT

By Day Allen Willey

A 10-FOOT SEAM IN AN ALABAMA HILLSIDE

THE fact that about 6,500,000 tons of bituminous coal were exported from the United States during the year 1900, or more than twice the quantity sold to foreign purchasers in 1898, — has caused the question to be asked whether this branch of American commerce is to be permanent, and, if so, what proportions it will assume. Were the sales confined to demands for coaling stations for foreign governments and for bunker use of vessels in foreign merchant marines, the matter would excite little comment, owing to the fact that 6,500,000 tons represent but a small fraction of the annual output from mines in the United States.

During the year under consideration between 170,000,000 and 175,000,000 tons of soft coal were produced; consequently the export trade represented less than 6 per cent, but shipments of fuel were made of 4412 tons to Great Britain, 169,800 to France, 10,756 to Germany, and 450,269 tons to Russia, Norway, Sweden, Italy, and Turkey, the bulk of it soft coal. Taking the same period in 1898 for comparison, the shipments aggregated 7844 tons to Great Britain, and but 19,222 tons to Northern and Southern Europe, with no tonnage to Germany or France. Here we have an increase in two years of 431,041 tons to Northern and Southern Europe, which have been among the most extensive markets for Welsh, German, and Belgian coal, 169,800 to France, and 10,756 to Germany, which are considered as nearly self-supplying countries for fuel for power purposes. Strikes in the Cardiff district, in France and Germany, formed extraordinary factors which contributed to the increase, but it is admitted that the labour situation was responsible for but a portion of the demand. As further proof of this fact, it may be added that during the month of December, 1900, contracts were made for 900,000 tons of American soft coal to be delivered during the present year at Russian and French ports alone. Another order for 100,-000 tons from the West Virginia mines

is to be supplied to Italian consumers also during 1901.

The use of American coal by foreign consumers has developed in a large measure from the custom of foreign ships, operating in regular and occasional service to American ports, "coaling" at these ports when it is impossible to take on enough at home ports to fill out the voyage. For instance, a British vessel chartered at London to carry cotton from America to the Asiatic market could not carry a supply to last her on the trip from England to a Gulf city, and from there to her next destination. Consequently, she proceeds to Mobile, Pensacola, Norfolk or some other port to fill her bunkers, and this trade has developed into a large tonnage annually within the last few years. Carried to the principal ports of the world, this bunker fuel has been the means of extensively advertising the American product, and its qualities have been compared with those of coals from other countries. This fact probably led to the orders from the British Admiralty, which was among the pioneer customers for American coal in cargoes.

During the past year tests were made of West Virginia coal for gas making in the city of London. Experts differ as to the superiority of the American article compared with the British coal which has hitherto been used. One objection offered, and an objection which has also been raised by Italian and French consumers, was that the American coal was more friable and could not be handled in lump form as well as the Welsh variety, for example; but the low price has undoubtedly proved a strong argument in favour of the Maryland, West Virginia, and Alabama mines from which the bulk of the export coal has been taken. Railway companies on the Continent have been purchasers for their locomotives. Another demand from Southern Europe is

SOME OF THE MINERS

A SIDE HILL MINE ON THE BALTIMORE & OHIO RAILROAD, SHOWING TRAIN OF OLD AND NEW STYLE CARS BEING MADE UP AT THE TIPPLE

for foundry use and for smithing. A portion of the consumption in Northern Europe is also for the same purposes. In fact, where purchased, the coal has been substituted with various results for the European steaming and smithing grades.

The localities from which it is secured are comparatively few, although the prospects for foreign business point to extensive shipments from other fields in the near future. The mines are located principally in the Warrior and Birmingham districts, in Alabama; in the Cumberland district, in Western Maryland, and in the New River, Kanawha, and Pocahontas, or Flat Top, districts, in West Virginia, the latter extending a few miles into Virginia. These areas represent but a small fraction of the 195,000 square miles of deposits which, it is estimated, can be found from outcroppings to a depth of 1000 feet. West Virginia alone has 20,000 square miles, the veins it contains averaging from 4 to 13 feet in thickness. Nature has contributed to aid mining by locating the deposits in basins, yet above the water-level; also on hillsides and among strata of soft rock All the varieties produced in this field,—the coking, gas, splint, and cannel,—can be found so situated that the expense of mine drainage is avoided.

The Maryland fields are a continuation of those in West Virginia, and the conditions are similar. The Cumberland companies, however, have the advantage of being from 100 to 150 miles nearer tide-water. The Warrior field, in Alabama, comprises 8000 square miles, representing no less than fifty-three seams, varying from 6 inches to 16 feet in thickness. They lie in proximity to deposits of iron ore and limestone, and are somewhat more expensive to work than the beds further north, owing to extent of the rock formation. The Alabama varieties worked are coking, gas, and what is locally termed "steam" coal.

Much of the American coal is yet untouched, for the reason that the mining companies have worked veins where entries could be made directly into the coal or where only 50 or 100 feet of

tunnel were required to come to the face of the seam. A few openings have been made on a level formation where it became necessary to sink the shaft vertically; but, outside of Western Pennsylvania, there are probably not ten plants in Maryland, West Virginia, or Alabama which require the raising of the material in this manner more than 150 feet.

The abundance and location of the veins have been among the principal reasons for the remarkably low cost of mining operations. It is well known that veins 10 and 12 feet in thickness can be found in all of the districts referred to, but a working on a 6-foot vein may be more profitable owing to greater ease of access. Still, operations in 10 and 12 foot veins are fairly numerous, both in Maryland and West Virginia, and a bed in the Birmingham district of the South was found last year outcropping on a hillside that contained 15 feet face of excellent coking coal.

Of all the various grades the New River and Pocahontas are perhaps best known abroad, owing to their extensive use on steamships. They contain the largest percentage of combustible matter of any American soft coal yet exported, the percentage of fixed carbon ranging from 75 to 85, while the percentage of volatile matter never goes beyond 20. Analyses made in other districts are as follows:—

	Carbon Percentage	Volatile Matter
Kanawha (W. Va.)	70 to 77	20 to 25
Cumberland (Md.)	72 to 74	18 to 20
Warrior (Ala.)	58 to 62	35 to 38
Birmingham (Ala.)	59 to 61	33 to 35

The changes which have taken place in the mining and transporting of American export coal within the last five years have been so marked that some methods in vogue at the beginning of that period have really become atiquated, such as the plans for loading at the mines, the working of the seams, the hauling of the product to the surface, the system of illumination and ventilation, the shipments by rail, the loading of the coal on shipboard, and innovations have more recently been made, too, in the construction of steam colliers. Even the mining communities have been modernised, so to speak, and the methods of providing habitations for the workmen revolutionised, perhaps with the view of exercising an effort to avert labour troubles.

The American mining village of to-day is generally built upon land owned by the company, and naturally in the immediate vicinity of the workings. The contract for the dwellings of the employees is let to one company, and consequently comfortable houses for single or groups of families can be constructed much more cheaply than when built separately. The power station, which is now a necessary adjunct, furnishes a system of lighting for the village, and, if it is large enough, waterworks are installed, as well as a sewerage system. The company may erect schools, and also boarding-houses for the unmarried operatives, and, owning the town site, through its real estate department, secures a moral influence which is very effective, while deriving substantial profits from the rental of its property.

ELECTRIC COAL DRILLING

The plan of mine surveys has differed

THE OLD WAY OF HAULING COAL FROM THE MINES BY MULES

THE NEW WAY WITH ELECTRIC LOCOMOTIVES

but little from past methods, the estimates of the depth, and direction, and quality of coal seams being calculated by borings from above and lateral test drifts, according to the topography of the country and character of the coal veins; but the main entry is driven in double instead of single form, each opening being wide enough to allow the construction of at least one track, in some instances two where the production is so large that a four-track tramroad is actually required. Space is also allowed for the installation of conduits for compressed air, pipes for steam where necessary, and the indispensable wiring for lighting and power purposes if electric apparatus is used for cutting and hauling.

In some of the larger mines ventilation is effected by fans located at suitable points on the surface over the galleries, connected with them by vertical air shafts. This plan is followed where the coal seams occur in proximity to the surface, otherwise the air is forced through the main entries and side passages. The plan of a modern soft coal mine is quite similar to a huge gridiron, the ridges left between the openings answering to the bars and the various chambers, and their connections with the main entrance representing the space between the bars, while the principal opening is the handle. As soon as the main entry is completed to the surface of the coal, it is diverted to extend parallel with the face of the vein, and from it the laterals, or galleries, are opened into the various "rooms," which correspond with the "chambers" of an anthracite mine. In the construction of the entry and its branches a grade is surveyed by the engineer which has, if possible, an upward incline from the coal tipple to all portions of the workings, in order to take advantage of the force of gravity, thus economising in haulage power. Quite a number of the plants in the export coal districts are worked from the sides of hills at an elevation from the railroad or water course which is their outlet, so that the coal is transported by gravity from the chambers to the dumping platform. The gridiron mine is popular for the reason that it is considered safer to cut out the chamber, leaving the pillars to be "robbed" after the chamber has been exhausted. In some of the operations in Alabama and a few in West Virginia the "long wall" method is partly followed. The main entry may be driven with branches extending obliquely, the rooms connecting with the branches. Another plan is to drive the entry entirely through the proposed working and make another at right angles, the galleries and rooms leading from each. Where the seams are thin and the surrounding formation loose or shaly, the "long wall" plan is frequently advantageous. As the main entry and laterals are narrower, less propping with artificial supports is needed, and all of the coal is secured at the first operation, dispensing with pillar robbing.

Although coal-cutting machinery is rapidly superseding handwork in seams where it can be installed, the use of the chisel and drill is still extensive for under-cutting, a miner taking the contract to remove the coal from a room and employing his own helper to load the tram-cars and clear away the débris. In handwork the grooves cut vary from 2½ to 4 feet in depth, according to the direction and thickness of the seam, made as near, of course, to its lower edge as possible. When the under-cutting is completed, the mass is broken out with wedges driven into the top of the seam. The use of explosives is also allowed, under the direction of the mine boss, as quite frequently a stratum of rock or slate is encountered, and blasting is then the most economical method. The miner is responsible for the safe condition of the chamber and entrance, and does the propping where there is danger of the roof or walls weakening. He is furnished the necessary timber for this purpose by the company.

When it is stated that in 1891 but 550 coal-cutting machines were in use in the United States, and that in 1900, 3000 had been installed in the soft coal district, mining about 45,000,000 tons,

the growing popularity of power mining can be appreciated. Apparatus for under-cutting by electric and pneumatic power is distributed throughout the export coal districts. Its principal advantages are in the saving of time and labour, the small waste in cutting as compared with hand tools, its cheap operation where a power plant is installed, and where work must be done as rapidly as possible to avoid possible flooding or caving in. It also does away with the necessity of explosives and the consequent danger of loosening natural and artificial support.

The apparatus is divided into punching and chain machinery and cutting discs, the former being used in galleries and entries where the face to be cut is not extensive. Compressed air is generally employed to operate the "puncher," which might be called a pneumatic chisel, and which cuts into the coal by rapid blows. Its performance is similar to that of a rock drill, but the machine is smaller and can be guided in a horizontal, vertical or oblique direction, at the will of the miner.

The chain machine is preferred in "long wall" mines and for breast workings in general, as it is much more rapid and produces less slack; but it requires more space. It consists of a steel platform supporting a movable steel chain or belt to which cutting points are bolted. The chain or belt revolves around its frame in a horizontal direction, rapidly or slowly, at the will of the operator, and the platform moves on rollers, being pressed against the vein by the same power which operates the chain. The chain platform is enclosed in a framework which supports the electric or air motor, as the case may be, and is held in place by legs braced against the walls. In places where the vein is only three or four feet thick and the gallery small, the operating mechanism is on a separate truck coupled to the cutting machine. In electric mining the current is conveyed to the motor by an insulated cable wound on a reel. This is connected with the power station, and is unwound as the apparatus is moved from one point to another.

CUTTING COAL WITH A CHAIN MACHINE

The machines are built to make

LOADING COAL INTO CARS BY THE MODERN TIPPLE METHOD

grooves of different depths. A miner and helper with an electric cutter can undermine from 700 to 900 square feet of coal in a day of ten hours, making a groove 6 feet in depth, and the saving in the cost per ton over hand labour is from fifteen to forty cents, according to the location and size of the seams. The disc cutter differs only in the cutting part, which, as the name indicates, revolves as it is forced into the coal.

While one section of the electric current generated from the power station is furnishing the mechanical muscle to mine the coal, another portion may be supplying the power to transport it to the tipple, that is, in places where the gravity system cannot be utilised. The motors take current from the overhead wire through trolley poles like those in use in ordinary electric street railway service. The motors are of various sizes and power. A 10-H. P. motor, weighing 2 tons, will haul about 33 tons on a level, 6 tons on a 2 per cent. grade, and 3 tons on a 4 per cent. grade at a speed of about eight miles an hour. A 25-H. P. motor, weighing 7 tons, will haul 66 tons on the level, 24½ tons on a 2 per cent. grade, and 13 tons on a 4 per cent. grade. A 40-H. P. motor, weighing 10 tons, will haul 117 tons on a level, 44 tons at 2 per cent., and 24½ tons at 4 per cent.; while a 55-H. P., 15-ton motor will take 183 tons on a level, 70 at 2 per cent., and 39 at 4 per cent. Where animal power is used, the average mule is calculated to haul from 8 to 10 tons on a level, the weight decreasing in proportion to grade. Of course, animals can be used only on slight grades.

The average cost of labour is exceedingly difficult to estimate, owing to varying scales of wages paid, time workmen, and the wide difference in the price for contract work. Naturally, the difficulty of the mining is an important consideration. In Alabama, miners have been paid from $2 to $2.85 per day, helpers from $1 to $1.50, and boys for drivers from 35 to 75 cents. Maryland miners receive from $2.25 to $2.75; helpers, $1.40 to $2; boys, $0.85 to $1.06; West Virginia miners, $1.90 to $2.25; helpers, $1.25 to $1.75; and

COKING IN THE ALABAMA FIELDS

boys, 50 to 85 cents. Most of the helpers in Alabama are coloured, and these are paid from 20 to 25 per cent. less than white. Consequently, the Alabama scale is considerably higher than elsewhere in the export field. The estimates are made after deducting from the miner's wages what he pays his helper when engaged on piece work. These computations are based upon hand mining. The scale for machine work is about the same. In a few localities machine operators receive from 5 to 10 per cent. less.

All estimates of the price of a ton of coal delivered at the tipple show the great reduction which has been made in the cost of production by the modern methods. The figures seem almost incredible compared with Welsh, Lancashire, and Continental estimates. The following figures are the averages from reports of companies in every coal-producing country of the States named:—

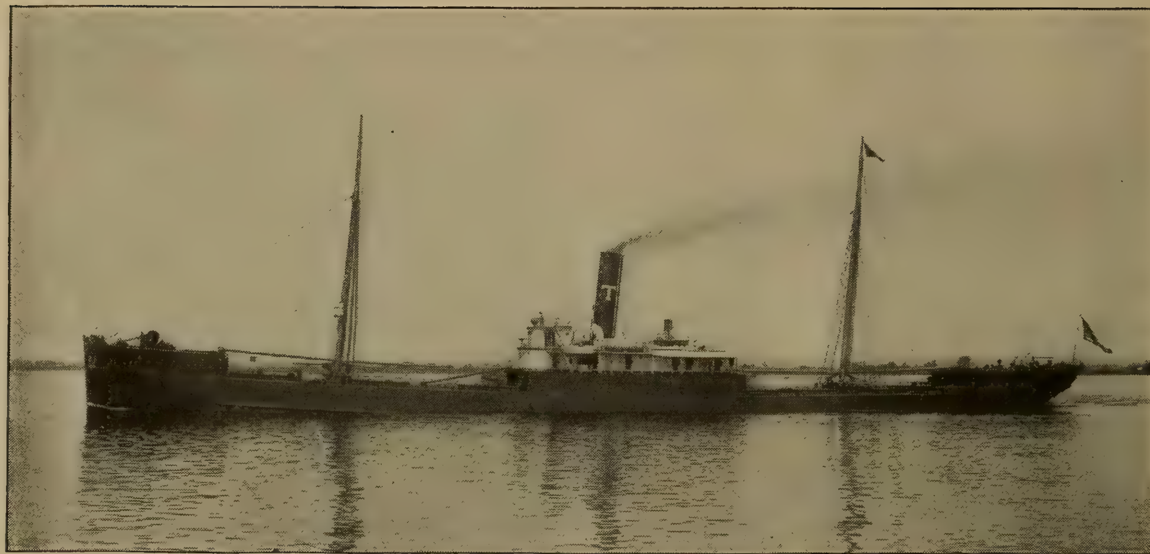
Alabama	95 cents.
Maryland	85 "
West Virginia	65 "

From this valuation may be deducted from 5 to 20 per cent. representing the profit of the operator, so that the actual cost of producing the export coal per ton is less than 90 cents in Alabama, less than 80 cents in Maryland, and about 60 cents in West Virginia, including wages, power, estimates for depreciation of machinery, interest on investment, taxes, and cost of transportation to tipple.

Most of the tipples in the districts where soft coal for export is secured are built of timber from the vicinity, erected to overhang the railway with which the mine is connected, or the water course. They generally cover at least three lines of rails, so that cars may be loaded at the same time with each of the three commercial sizes. By the plan followed the coal is dumped, separated, weighed, and loaded practically in one operation. The cars run out on a movable platform inclined to an angle of about 30 degrees. By opening the lower end their contents are thrown upon the separation bars and thence transferred to a weighing platform which automatically dumps it into the car below or into the hold of the vessel. One man and helper can operate a tipple which can transfer enough material to make up a trainload of forty 50-ton cars in six hours. If it is desired to save time, and an order is to be filled for "run of mine" coal, a train of "empties" is made up, attached to a locomotive, pulled under the tipple, and as fast as each car is loaded it is hauled out and the one behind placed in position. The "caboose" has already been attached to the rear end, and when the last car is loaded the train is ready to start for tidewater or other destination.

The tendency to build rolling stock of larger and larger proportions has resulted in the use of steel to a considerable extent in place of wood for the framework and covering of coal cars. The "jimmy," so familiar on American railways a few years ago, and the cause of so many accidents from its liability to leave the rails, has almost entirely disappeared. The gondola type, holding from 30 to 40 tons, or three times the capacity of the "jimmy," is also giving place to the 50 and 55-ton receptacle, which is much more easily handled in train service. A pressed-steel car of 80,000 pounds capacity weighs 28,500 pounds, a ratio of 35.62 per cent. One of 100,000 pounds capacity weighs 35,500 pounds, a ratio of 32.27 per cent., while the average wooden car that carries 70,000 pounds of coal weighs 35,000 pounds; the pressed-steel car carrying 110,000 pounds of coal weighs only 500 pounds more. The wooden car carries coal equal to twice its weight; the pressed-steel car, three times its own weight, with 3500 pounds to spare.

Estimates show that the 80,000-pound wooden cars of the Pennsylvania Railroad are built at a cost of $800 each, while the pressed-steel car of 100,000 pounds capacity costs about $1000. The average life of the wooden car is about fifteen years, with $35 a year for repairs, and the ordinary life of a pressed-steel car is calculated to be fifty years, with repairs costing $10 to $15.



THE STEAMSHIP "PLEIADES," AN AMERICAN COAL CARRIER

As an indication of the increasing demand for this rolling stock, it may be stated that, four years ago, the steel-car industry was in its infancy; two and one-half years ago it employed 2000 hands; to-day fully 20,000 men and boys are earning their living at it.

It is hardly necessary to note the increase in size and power of the locomotives on American coal-carrying railways, and that in the rehabilitation of the systems mentioned the lighter rails have been replaced by metals weighing 70, 80, and 100 pounds per yard; bridges have been replaced by heavier structures, and roadbeds ballasted with stone 12 to 20 inches deep. Trainloads of coal have been increased from 1200 and 1400 tons to 2000 tons, while it is not unusual for a modern "Consolidation" engine to move from 2300 to 2500 tons from the mines to tidewater.

Most of the railway companies are fortunate in having a down grade for a considerable distance from the mines to the seaboard, which further explains the fact that they are handling this grade of freight as cheaply as four-tenths of a cent per ton per mile and yet earning a profit on it, as illustrated by the reports of the Chesapeake & Ohio, the West Virginia Central, and other companies. The invention of the air brake allows such a tonnage to be transported with no increase in the train crews.

The principal method of transferring from car to vessel at the export point is by the chute, which is partly responsible for the powdery condition in which the American coal reaches the foreign market. There the force of gravity again is used, but the rapidity and small expense attending the plan are factors in its favour. Arriving at tidewater, the cars are switched upon elevated piers, which are long enough and high enough to allow steamships and sailing vessels carrying from 4000 to 10,000 tons of cargo to be moored alongside. The piers are built with a series of openings under the tracks, which connect with chutes of iron terminating in movable legs or pipes reaching to the hatchways of the vessels to be loaded. A car is rolled over one of the holes, and a trap door in the bottom is opened by pulling a lever. The contents slide down the chute through the leg and into the hold of the vessel. At the upper, or water, end of the pier, a switch is constructed which connects with a track inclined enough to allow the empty car to run back from the pier to the shore terminus by its own weight, where it is made up into a train and started back to the mines.

The larger piers are wide enough for two sets of tracks and a series of chutes on each side, so that two lines of vessels can be loaded at once A 50-ton coal car can be emptied by this method in five and a half minutes from the time

the door in the bottom is opened. Including the interval occupied in switching a train of cars on to the pier, unloading them and running them back to the shore, the process occupies from fifteen to twenty minutes. It is, of course, necessary to allow time for delays in running trains upon the pier and in stopping and starting the cars, but from 1500 to 2000 tons can be readily handled in an hour's time.

The bulk of export soft coal goes on shipboard at Port Richmond and Greenwich Point, near Philadelphia; Locust Point and Curtis Bay, on Baltimore Harbour, and Lambert's point and Newport News, on Hampton Roads. A small tonnage outside of bunker coal has been placed on board ship at New Orleans, Mobile, and Pensacola, Fla. Most of the European shipments have gone by way of Baltimore, Norfolk, and Newport News. The Philadelphia & Reading Railroad Company controls the Port Richmond terminals, which have a total pier length of 5500 feet. The Pennsylvania Railroad Company ships from Greenwich Point, having about 5000 feet of coal pier frontage. The facilities at Port Richmond and Greenwich Point, however, are used for loading a large fleet of schooners and barges in the domestic bituminous and anthracite trade, and their combined export tonnage is less than 15 per cent. of the total.

The Curtis Bay pier, the largest in the United States for soft coal exporting, is 800 feet long and 75 feet wide, and vessels of 20,000 tons combined capacity can be loaded from it at one time. Its chutes will transfer 40,000 tons in twenty-four hours of continuous service. It extends to a height of 45 feet above low tide, and cost $350,000. The Locust Point pier is about one-half that size. Both piers are controlled by the Baltimore & Ohio Railroad, and are loading points for Maryland and West Virginia fuel. The Norfolk & Western Railroad Company controls the pier at Lambert's Point, which is about 600 feet long. From it 30,000 tons have been handled in twenty-four hours. A contract has been let for another, which will be 700 feet in length, and which is to be completed during the present year. With it between 50,000 and 60,000 tons can be transferred in twenty-four hours if necessary. Newport News has two chute piers, being the railway terminus for coal from the Kanawha and other West Virginia districts. Their combined loading capacity is 30,000 tons in the time specified. The Louisville & Nashville Railroad Company, which ships Alabama coal from Pensacola, has facilities for loading about 15,000 tons, although its single pier has as much capacity as those at Mobile and New Orleans combined. The Alabama fields also furnish the output of the latter cities.

The export tonnage of American soft coal has found its way to the market mainly in "tramp" steamships, although cargoes to Mexico and the West Indies have been taken from Philadelphia and Baltimore by fleets bringing ore from the Cuban mines to American furnaces. The problem of water transportation for coal has been by far the most difficult to solve, owing to the variety of other export business offered to "tramps" and line shipowners. Scarcity of suitable bottoms has been the great trouble in the trade, and only the minimum price quoted at tidewater has enabled exporters to pay the ocean freight demanded. This is one reason why the question of building a type of vessel in the United States to carry coal at a rate under the average secured by foreign shipping companies has been considered.

Already two such ships have been completed, and their performance would seem to indicate that an American collier can be built which may be operated with more economy than foreign ships of the same speed and tonnage and transporting low-grade cargoes. The *Pleiades* and the *Hyades*, the vessels referred to, were built by the marine department of the Maryland Steel Company, at Sparrow's Point, Md., and have been in commission about two years. They are identical in dimensions and model, being 345 feet in length over all, 47 feet beam, and 28 feet

depth of hold, giving cargo space for 5500 tons, allowing a bunker capacity of 750 tons of fuel. They are built of steel throughout to rate in the highest class of both American and British Lloyds. In size they rank with the smaller class of British "tramp" ships, so many of which have been completed within the last few years. They have triple expansion engines driving a single screw. An average based upon the calculations made during several trips, with and without cargo, shows that these ships can maintain a speed of 10 to 10½ knots an hour with a fuel consumption of only 23 tons in twenty-four hours, developing 1400 horse-power,—an average of 1.36 pounds of coal per horse-power per hour. The coal used was ordinary "run of mine" from the Cumberland district. Only thirty men all told are needed to man each ship, as they are fitted with steam winches to each hatch and all of the latest labour-saving devices for handling cargo. The price paid by the Boston Steamship Company, their owners, for the two averaged $250,000 each. Since they have gone into commission the company has ordered two more from the Sparrow's Point yard. These are to be about twice the size of the original vessels, and of the same speed, with 11,000 tons cargo capacity. All will be classed as "tramps" to take cargo wherever ordered.

As yet, none has carried a load of coal across the Atlantic, but, based on their performance in the coasting trade, the claim is made that they can take charters at 5s. per ton maximum freight for any British port, and at 6s. 6d. per ton to Southern Europe, at 10 per cent. profit, allowing for fuel, wages, maintenance of crew, insurance, pilotage, depreciation of hull and machinery, and interest for time of voyage on cost of vessel. With the price of coal 10s. to 12s. per ton delivered on shipboard, it could be delivered at any of the ports referred to at a total cost of not over 20s. per ton; yet during 1900 a vessel loaded at Baltimore for Genoa, the freight alone being 12s. 6d. per ton, and a number of charters were taken out for Northern Europe at 14s. per ton. From these figures, taken in connection with the cost of the fuel at the tipple and estimates for rail transportation, a fair calculation can be made as to the influence which bituminous coal from the United States will exert in future in the markets where it has been introduced.

ELECTRIC VEHICLES VS. TRAM-CARS

A POSSIBLE DEVELOPMENT OF THE FUTURE

By Alton D. Adams

VEHICLES, driven by storage batteries and electric motors, are now a recognised means of transportation, but the importance and extent of the service they are to render in city streets remains to be determined. Opinions are freely expressed that electric motors will displace the horse with independent vehicles for urban purposes, but the possible competition of such vehicles with the present tram-cars has received little attention.

Passenger transportation in city streets has developed by a series of revolutionary changes. It was a long step from the bus, free to travel in any part of any street, to the tram-car, confined to a single route in those streets where rails were laid. Even more radical was the change from animal power, appplied at each car, to steam power, developed in one or more central plants and distributed by a moving cable beneath the surface of the street. Greatest of all was the innovation when a stationary electric conductor displaced the moving cable, and a single generating plant was able to move hundreds of electric cars in scores of different directions at the same instant of time.

Looking back at these several changes in the methods of passenger transportation, the main incentive to each is seen to have been cheaper operation for a given service. The operating cost per passenger per mile carried is less for the horse car than for the bus, less for the cable car than for the horse car, and least of all for the electric car. This gain in purely operating expenses has been great, but it has not been attained without sacrifices in other directions.

Fixed charges on the investments, limitations in the flexibility of systems, and objectionable structures in streets have multiplied as the expenses of operation have diminished. Perhaps the only exception to this last statement is found in the change from cable to electric traction, which brought increased flexibility of operation as well as larger investment. The capital invested in bus and horses per passenger transported was very small. These vehicles could travel in any part of any street, required no special structures underneath or overhead, and most of the charges against them were those simply of operation. Horse cars required a considerable increase over the investment necessary for transportation by bus, both because of their heavier structure and more on account of the cost of rails. With cable cars, the fixed charges per passenger advanced another and larger per cent., while the track became more highly specialised. It remained for the system of electric traction to reach the maximum of investment per unit capacity of equipment, and to introduce aerial as well as surface structures in the streets.

That electric tram-cars effect so great a saving in operation as to more than offset the higher first cost and other disadvantages of the system, compared with any that preceded it, may be taken as proved by their extensive and extending application. It by no means follows, however, that electric tram-cars, operated over definite routes, in connection with elaborate overhead structures, and all directly dependent on a distant power station, represent the final development of transportation in city streets.

Electric tram-cars are apparently near the end of a long line of development,

of which the main object has been reductions in operating expense for certain qualities of transportation service, though the standards of quality have much improved. If the perfect tends to disappear, and little more is to be expected in the reduction of operating expenses for electric tram-cars, the time seems ripe for the advent of a new system of public transportation in city streets. Electric vehicles constitute the elements of such a system. These independent vehicles, driven by their contained batteries, seem ready to carry forward the development of city transportation toward smaller investments and fixed charges per unit capacity, greater flexibility of service, and freedom from all special structures in the streets.

Against the view that vehicles, independent of any rails or structures for power transmission, can displace electric tram-cars, it is urged that the cost of operation for such vehicles is too high to allow them to seriously compete in the great bulk of public transportation. To compare the advantages of tram-cars and independent vehicles, driven by batteries, for passenger traffic in city streets, the savings of the former, if any, as to purely operating expenses should be weighed against the low investment, flexibility of operation, and freedom from the street structures of the latter. It is, of course, understood that in some limited classes of transportation, such as that by cabs, it is simply a question between independent motor or horse vehicles.

Though data are not at hand to show the exact disadvantage, measured in money, of tram-car rails in the streets, it is a matter of general observation that this disadvantage, including the frequent digging up of pavements, is large. The overhead structures generally used with electric tram-cars are by no means so objectionable as they have sometimes been made to appear, but few will contend that they add to the beauty of streets. There seems to be little doubt that the substitution of independent battery motor vehicles for electric cars would result in much quieter streets, through the use of wheels with rubber tires or tires of some other comparatively noiseless substance.

As tram-cars are confined to a fixed portion of the streets in which rails are laid, travel in them must be confined to these streets. A result is, where several streets go in the same general direction, that the cars are generally congested on parts of such streets, whereas independent motor vehicles might use all of these streets with equal facility. In cases of accident, by which a line of tram rails is temporarily closed, travel on certain lines is, at times, seriously impeded. One of the most notable features of the demand for urban transportation is its concentration at certain hours of the day, and in most instances it is impossible to move cars over existing lines of rails fast enough to meet the maximum demands. Such lack of capacity is due not only to the fact that rails are laid in only a part of existing streets, but also to the inability of cars going in the same direction in one street to either pass one another or to travel two or more abreast, as independent vehicles can readily do.

Coming to the matter of investment for the system with independent vehicles, driven by storage batteries, as against the present system of electric cars, both require generating stations. The maximum capacity of the generating station necessary for independent electric vehicles is much less than the capacity necessary for the operation of tram-cars where the total daily output of energy is the same in each case. This difference in the necessary station capacities for these two traction systems is due to the very unequal demands made on a power station by tram-cars at different times of day. However short the period during which the maximum demand on a power station is made, the capacity of the equipment must be sufficient to meet it. For about one hour at the close of the business day the demands on power stations by tram-cars are often three or four times the average load during each twenty-four hours.

Such demands are usually met, in large part, by an equipment of boilers,

engines and dynamos larger than required by the average demand, and also frequently, to some extent, by an auxiliary plant of storage batteries, these last being located either at the main station or at sub-stations. But the differences in amount between the maximum and average loads at the power stations of electric railways are much greater than it has been found desirable to supply with storage batteries alone, and the equipment of boilers, engines and dynamos at such stations, therefore, often has a capacity two or three times as great as the average load. A change from tram-cars to independent electric vehicles would make it at once practicable to develop the necessary electric energy for each day at such times as are most advantageous, instead of those times when it must be used. In other words, a generating station for independent vehicles could have its equipment of boilers, engines, and dynamos proportioned for the average instead of the maximum demands of the transportation system.

It follows that, for a given daily output of energy, the station to charge storage batteries for electric vehicles need have only one-half or one-fourth the capacity in generating machinery that is necessary for the operation of a tram-car system, and would require no battery plant whatever. With this smaller generating equipment the investment for land and buildings is likewise largely reduced.

Electric cars have thus far remained very heavy and expensive in construction per unit of passenger capacity. These features of such cars are largely due to the requirements of use on fixed steel rails, where an accurate and very rigid construction is necessary, and in order to meet these requirements the familiar construction with cast-iron wheels and heavy steel frame has been adopted. Partly from custom and partly from the necessities of the case, the bodies of electric tram-cars are heavier than would be the bodies of independent vehicles of equal carrying capacity. In view of their weight and expensive construction, it is safe to assume that the cost of independent vehicles, to be driven by storage batteries, would be no greater than that of the cars, per passenger capacity, not including the cost of the batteries.

The cost of storage batteries and also their weight for a vehicle of given passenger capacity and power requirements depend, in large measure, on the time during which a single battery equipment, or a single charge of that equipment by the generating station, must supply energy to move the car. So long as the maximum rate of energy output of the storage batteries is not exceeded, the weight of the batteries necessary to supply any given power may be reduced directly as the time is reduced during which the power must be furnished. The importance of this property of battery equipments, in its bearing on their weight, may be seen from the fact that batteries of standard makes may be discharged without injury in as short a period as three hours. This capacity for rapid working makes it possible to reduce the weight and cost of vehicle batteries to a very moderate figure, provided they can be replaced or recharged at short intervals, corresponding to the minimum periods of discharge.

An extensive system of transportation with independent vehicles in city streets may readily take advantage of this rapid discharge capacity to any desired extent, because the conditions of operation would permit the batteries to be charged and recharged at short intervals. Charging stations could easily be so arranged that each vehicle engaged in town or city transportation could pass one of them at least once during each period of battery discharge, even at the maximum normal rate. With suitable arrangements at the charging stations the discharged batteries could be removed from a vehicle, and others, newly charged, put into position during less than one minute.

Though the discharge of batteries at their maximum, normal rate makes it possible to maintain a given rate of work with the least possible battery weight, such a practice involves some loss of

efficiency, and this loss must be weighed against the advantages of light weight for each particular case. For purposes of illustration, a rate of discharge that brings the battery to the point of recharging at the end of a five-hour period may be assumed as one that combines high efficiency of operation and moderate weight. An independent electric vehicle seating twenty people may be fairly taken to weigh four tons, complete with batteries and passengers. Tests on a considerable number and variety of electric vehicles have shown that 100 watt-hours are a sufficient allowance of energy delivered to motors per ton-mile of transportation.

Allowing ten miles per hour as the travel of each car, the transportation during five hours is $10 \times 4 \times 5 = 200$ ton-miles. Since 100 watt-hours or 0.1 kilowatt-hour are required per ton-mile, the vehicle with twenty people consumes $200 \times 0.1 = 20$ kilowatt-hours during its five-hour run. One hundred pounds are sufficient allowance for weight of battery per kilowatt-hour of capacity, so that the battery weight for this case is 2000 pounds.

As the maximum number of cars or vehicles in a system is in use during only short periods daily, it is probably sufficient to allow one and one-half complete battery equipments for each vehicle, so that at least one-third of all batteries may be charging even at times when all vehicles are in use. The capacity of the total battery equipment per vehicle on this basis is thirty kilowatt-hours, and, at a price of, say, $30 (or about £6) per kilowatt-hour, its cost is $900 (£180). As the batteries on each vehicle are here proportioned for a delivery of twenty kilowatt-hours during five hours, their rate of work is four kilowatts.

The cost of electric generating stations, including land, buildings and all equipment for the development of electrical energy may easily reach $300 (£60) per kilowatt of output capacity. Four kilowatts capacity at a generating station, to deliver energy at the same rate as the batteries on each car, costs, therefore, $1200 (£240). If one-half of the generating capacity at the station can be dispensed with, where vehicles with batteries are used, because of the long and uniform load which they afford, one-half of the cost of the station may be saved, or two-thirds of the total battery cost. The higher efficiency of the system with battery vehicles, compared with that of electric cars supplied directly by the power station, will still further reduce the comparative costs of generating equipment for the two cases.

Coming to the cost of rails and electrical circuits for the tram-car system, it may be noted at the outset that these items are entirely absent in the system with independent vehicles. The cost of rails and of the overhead and underground electric circuits that connect cars with power stations is usually much greater than that of any other element in a street railway system. To show the relative investment in rails and electric circuits, compared with that necessary in other property for street railways, the table on the opposite page has been compiled from the annual report of the Massachusetts Board of Railroad Commissioners in 1900. In the items of railway cost the total investment, for each case, in rails and overhead and underground electric circuits is included. Under cost of equipment are included all investments in cars and other vehicles, and a few horses, and that in furniture, tools, and minor machinery. The cost of land and buildings includes power stations and their equipment, and all other land and buildings necessary for the operation of the railways.

In the case of the West End Street Railway Company the item under land and buildings is believed to cover a large amount of real estate no longer used for railway purposes, and this probably accounts for the unusual percentage of the total investment under this head. The total cost shows the entire permanent investment in the complete railway system for each case. The percentage of total cost in railway in the table represents the ratio of the investment in the railway and electric construction, divided by the total in-

COST OF SOME AMERICAN ELECTRIC STREET RAILWAYS

Costs	Springfield Street Railway Company	Worcester Consolidated St. Ry. Co.	West End Street Ry. Company
Railway	$1,168,061.87	$1,228,011.32	$9,022,765.30
Equipment	450,652.20	316,400.62	6,909.277.95
Land and buildings	703,932.05	205,454.21	10,778,311.63
Total investment	2,322,646.12	1,749,866.15	27,002,629.98
Percentage of total cost in railway	50.2	70.1	33.4

Costs	Lynn and Boston Railroad Company	Lowell and Suburban St. Ry. Company	Lowell, L. & Haverhill St. Ry. Co.
Railway	$4,432,259.71	$1,279,249.24	$1,747,864.17
Equipment	1,446,087.22	339,830.07	678,676.47
Land and buildings	1 442,889.32	584,521.90	670,645.82
Total investment	7,321,236.25	2,364,391.16	3,099,349.c6
Percentage of total cost in railway	60.5	58.3	56.3

Costs	Repairs on Track and Electric Lines	Cost of Electric Energy
Springfield Street Railway	$39.222.71	$48,777.48
Worcester Consolidated Street Railway Company	29,292.28	84,626.71
Boston Elevated Ry. Co. operating West End St. Ry. Co.	969,360.86	462.482 52
Lynn and Boston Railroad Company	86,151.55	96,256.10
Lowell and Suburban Street Railway Company	16,448.22	21,470.22
Lowell, Lawrence and Haverhill Street Railway Company	27,380.15	42,712.74

vestment. If battery-driven vehicles were substituted for electric cars, the investments for railway and conductors, averaging more than one-half of the total, would be entirely avoided, and the investment in land and buildings, with generating machinery, largely reduced.

The table also shows the cost of repairs on tracks and electric lines, and the cost of electrical energy for motive power per year. The former varies from less than one-half of the latter, as at Worcester, to more than twice the latter as at Boston. Such variations are probably due, in large part, to the differences in extent and character of paving in the several cities, and also to the fact that electrical energy is more economically generated in the larger plants. If vehicles with batteries displaced the present tram-cars, the entire item for repairs on rails and line would be avoided, and this amount, as shown by the table, may be taken as approximately equal to the present cost of motive power.

There seems to be no good reason to expect an increase in the cost of electric motive power if battery vehicles are substituted for the cars in any given system. The total average weight per passenger should be about the same for battery vehicles as for the present cars, and any disadvatage of pavements compared with rails, as to rolling friction, would be nearly offset by larger wheels on the vehicles. In the generation of the electric energy a station charging vehicle batteries would have a great advantage in economy of operation over a station delivering energy directly to street railway lines, because, as already mentioned, engines and dynamos could be worked at nearly full and uniform loads in the former case. In tram-car systems, as now operated, a part of the dynamo outputs goes first to station batteries, but the greater portion flows at once to the car motors. The energy that goes first to batteries is subject to a double loss, as it must also pass through the line to the motors. Energy supplied to vehicle batteries would be subject to no loss in lines, but only to that in the battery, which may be taken at 30 per cent. of the total.

The loss of energy in the electric lines and in the rails that connect station dynamos and car motors is subject to great variations in different systems, but 20 per cent. is probably as low a figure as can fairly be assigned to this loss on an average. As line pressures at car motors are approximately constant, while the motor speeds must vary over a wide range, a rather large loss occurs either in motor windings, designed to aid in the regulation of speed, or else in special resistances outside of the motor, for a like purpose. Speed

regulation of motors on vehicles driven by batteries is attained by changing the motor and battery connections, so that the voltage at motor terminals corresponds to the motor speed desired, and much of the loss in windings or external resistances of car motors is avoided.

Considering the loss of energy in station batteries and the loss involved in the regulation of speed for tram-car motors, it seems certain that battery vehicles of large capacity will receive from their motors as large a percentage of the dynamo output as tram-car motors deliver to their axles. If this last conclusion be correct, battery vehicles may receive a larger share of fuel energy from their motors than do tram-cars because of the higher economy of operation at the charging stations.

Inspection of the table on the preceding page shows that the cost of land, buildings, and generating plant is in most tram-car systems only from one-half to one-third of the investment in rails and electric circuits, and it has been shown that the cost of generating plant and of vehicle batteries combined is only about one and one-fourth times the investment for the generating plant alone in a tram-car system of equal passenger capacity.

It seems certain also that the repairs on the batteries of a vehicle system can be made at an annual outlay of not more than that now necessary to repair electric lines, rails, and one-half of the generating plant. There remains, then, as an unbalanced advantage of transportation with battery vehicles, a saving of about one-half of the entire first cost, and also of one-half of the annual interest charges of present tram-car systems.

MODERN TYPES OF BRITISH LOCOMOTIVES

A REVIEW OF DESIGNS AND PERFORMANCES

By C. J. Bowen Cooke

IT is thought by some people, and much has been written and said to show, that, in regard to modern railway practice, Great Britain, the pioneer of the world's railways, is being left behind. In an article entitled, "The Fastest Trains in the World," that appeared in the London *Times* last year, the working of certain express passenger trains in America, France and Great Britain was reviewed, and a perusal of that article would probably leave the reader under the impression that British locomotives are not capable of performing the work that has to be done on the railways of the other two countries mentioned.

The "Atlantic Flyer," which is timed to run from Camden to Atlantic City, in the United States,—a distance of 55½ miles in 50 minutes,—is quoted as attaining the highest point that has been reached by any railway in the world in the matter of speed and weight of train. From a return given in the same article, it would appear that the engines working these trains are daily making up time, and instances are recorded of a speed of 70 miles an hour being kept up from start to stop, with a load of 234 tons behind the engine. In regard to the question of speed, it was demonstrated half a century ago that locomotive engines, under certain conditions, could accomplish 70 miles an hour. The limit of speed is determined by the number of times per minute it is possible to cause the piston to travel backwards and forwards in the cylinder, whence it follows that the larger the practical diameter of the driving wheel, the higher the possible speed that can be got out of the engine. A Ramsbottom passenger engine, of the famous "Lady of the Lake" type, the standard express passenger engine on the London & North-Western Railway between 1860 and 1870, with single driving wheels 7 feet 6 inches in diame-

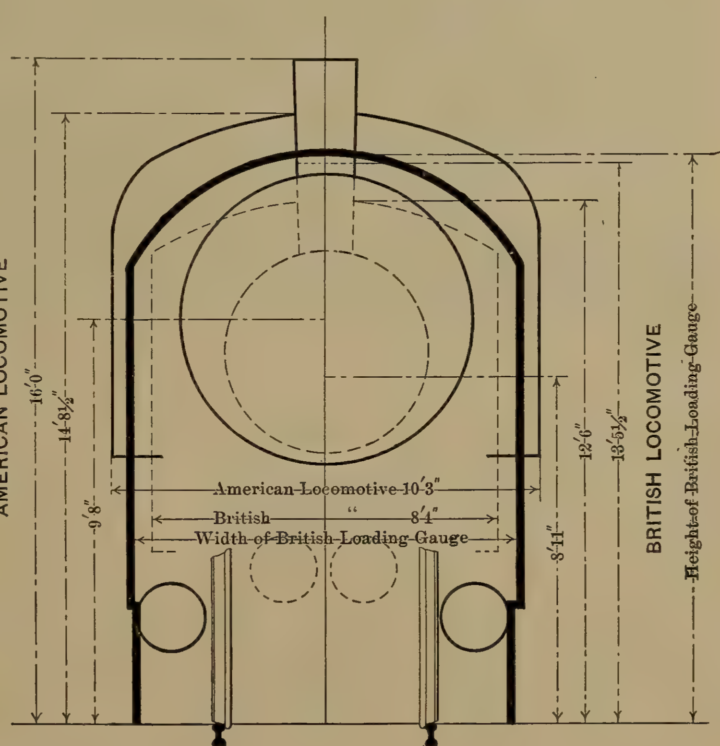


FIG. I.—COMPARATIVE DIAGRAM OF BRITISH AND AMERICAN LOCOMOTIVES

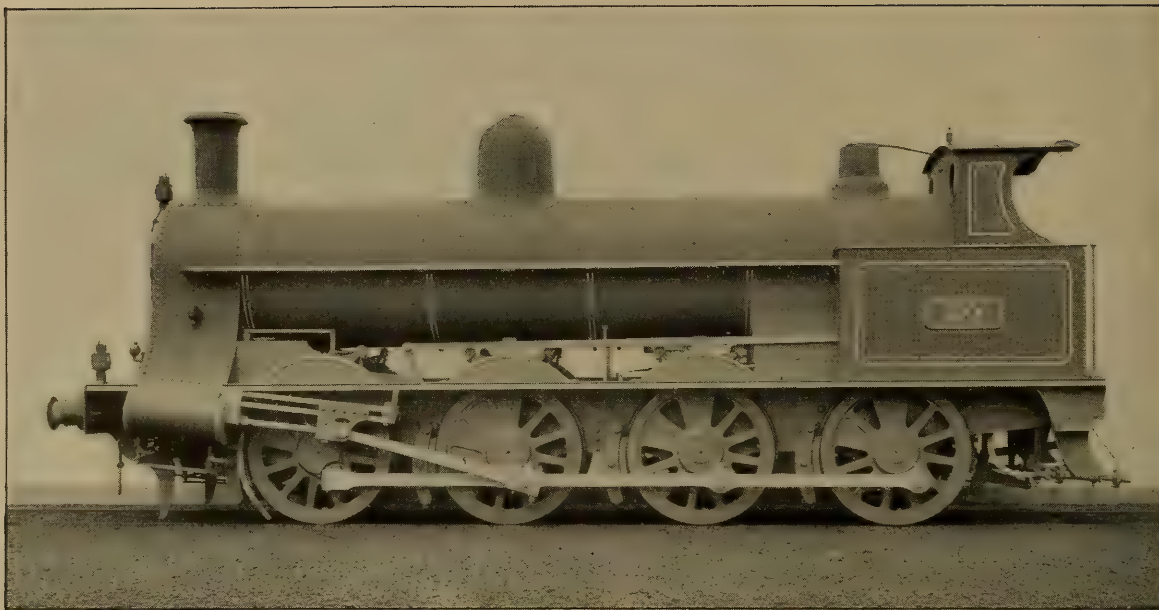


FIG. 2.—WEBB'S EIGHT-WHEELED COMPOUND COAL ENGINE. LONDON & NORTH-WESTERN RAILWAY

FIG. 3.—ASPINALL'S EIGHT-WHEEL COUPLED GOODS ENGINE. LANCASHIRE & YORKSHIRE RAILWAY

ter, and a stroke of 24 inches, when travelling at the rate of 70 miles an hour, has a piston speed of about 1048 feet per minute. The " Lady of the Lake" could originally travel at this speed, and can do so to-day; but when this was the standard passenger engine, the British express passenger train weighed only about 120 tons.

The increase in the weight of trains brought about the necessity of coupled wheels to increase the grip on the rails; and the coupling of the driving wheels to another pair necessitated a considerable reduction in their diameter, 6-foot 6-inch wheels being generally accepted as a convenient size. But this reduced diameter at once brought about an increase of piston speed, and a standard 6-foot 6-inch coupled passenger engine, when travelling at 70 miles an hour, develops a piston speed of 1204 feet per minute.

The weight of passenger trains has

increased so enormously of late years that the problem with which the locomotive engineer of the present day has to grapple is to build an engine so powerful that it can maintain the necessary piston speed whilst applying to the driving axle the additional power required to enable the engine to draw loads of 300 tons and upwards. This greater power can be obtained by lengthening the cranks; but here at once the piston speed difficulty presents itself. What is gained by the increased leverage is more than counterbalanced by the higher piston velocity; and, again, taking 70 miles an hour as a standard speed limit in ordinary running, a 6-foot 6-inch wheel with a 28-inch crank would develop the impracticable piston speed of 2809 feet per minute, without increasing the number of strokes.

We, therefore, find that, to gain this absolutely necessary increased power under modern conditions, locomotive engineers generally have been expanding the cylinder diameters, increasing the boiler pressure, and enlarging their boilers to obtain increased heating surface, grate area, and steam space The ordinary simple engine of to-day has cylinders varying from 18 to 20 inches in diameter, and a boiler pressure of about 200 pounds per square inch. But the British engineer, whilst he can enlarge his cylinders and increase his boiler pressure, cannot follow the lead of his American cousin in the matter of boiler construction; and his chief difficulty is to design a boiler of sufficient capacity to supply steam continuously, at the full working pressure, to cylinders whose piston surface has increased from 201 to 298 square inches This difficulty originates in the fact that no locomotive in Great Britain may be more than 13 feet 6 inches above rail level at its highest point, whilst the width of every locomotive is restricted by station platforms and by the close proximity to each other of the British tracks. It will be obvious that a national alteration in the width of the 6-foot way, involving a setting back of all station platforms and widening of all tunnels, means an expenditure that would not be justified by the comparatively trifling increase of speed obtained.

Fig. 1 shows, in black lines, the external dimensions, in width and height, of a modern American engine, whilst the dotted lines show the external dimensions of the latest Lancashire and Yorkshire passenger engine, which has attained the extreme limit possible with the British loading gauge. The heavy black lines show the British loading gauge which no dimension must exceed. This, without comment, will give some idea of the different conditions under which British and American engineers have to work to attain the same standard of boiler efficiency.

Fig 4 will show, at a glance, how the

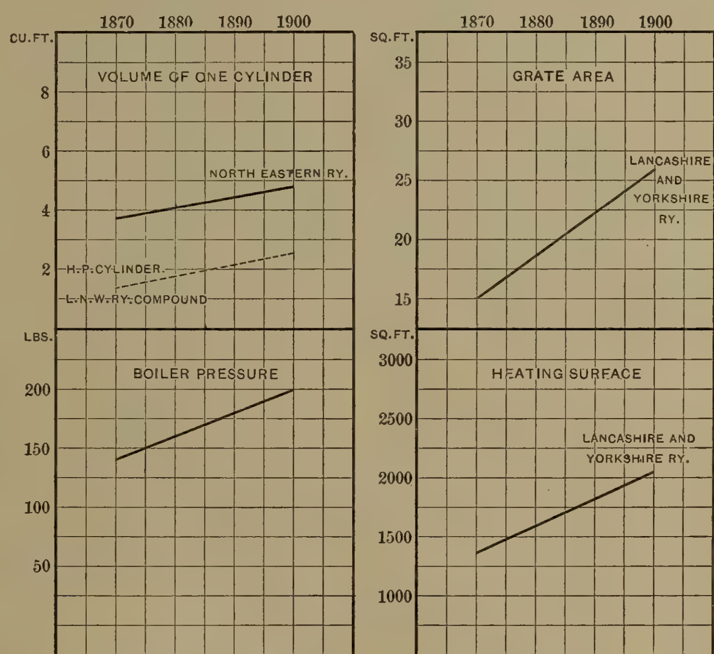


FIG. 4.—THIRTY YEARS OF LOCOMOTIVE GROWTH

heating surface, grate area, boiler pressure and volume of cylinder have increased during the last thirty years. The data for the year 1870 have been taken from the general practice on the leading railways, as given in "Hutton's Engineers' Hand-Book," a well-known

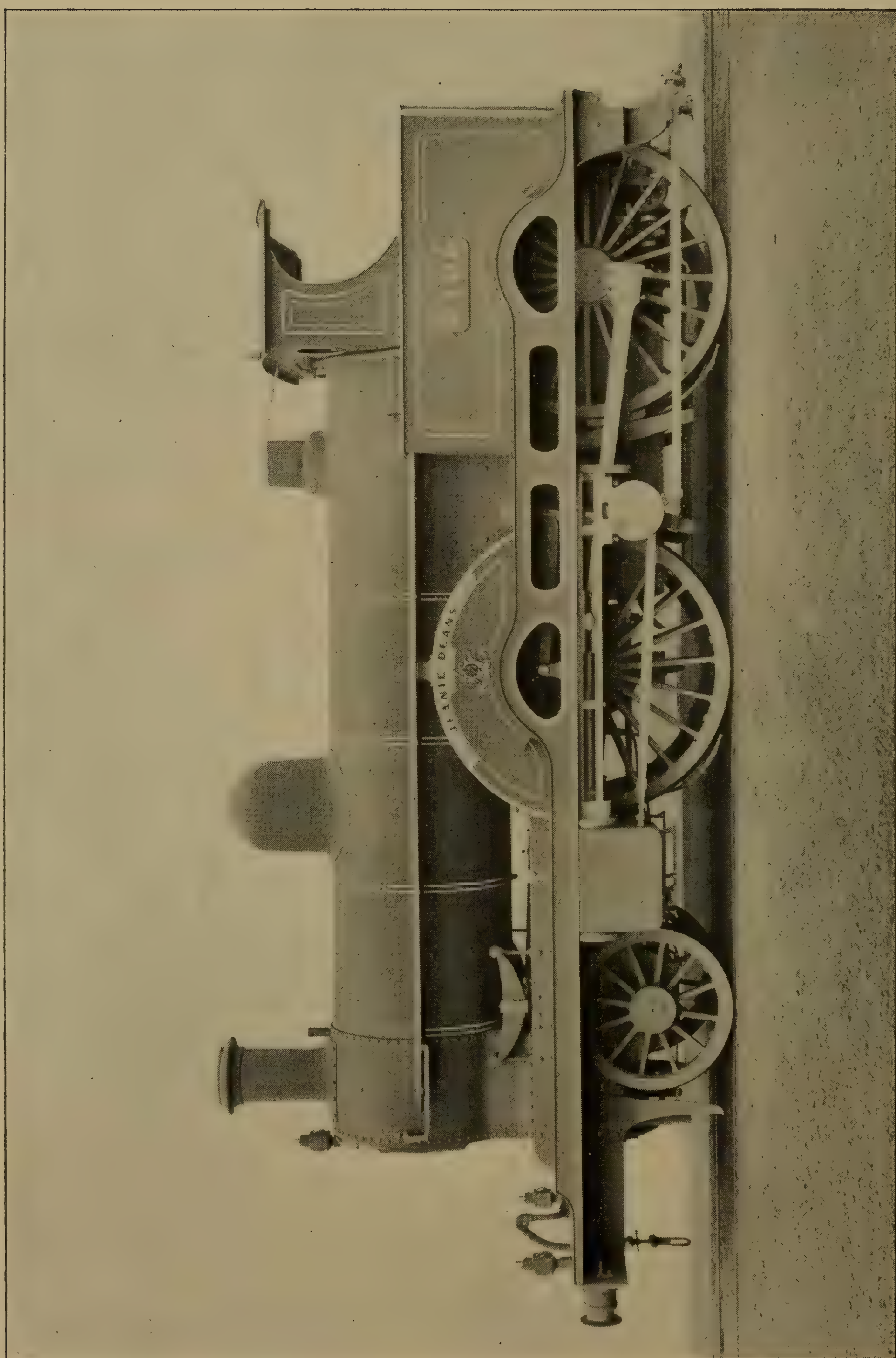


FIG. 5.—WEBB'S COMPOUND PASSENGER ENGINE "JEANIE DEANS" WITH SEVEN-FOOT DRIVERS. LONDON & NORTH-WESTERN RAILWAY

and reliable work. From these figures the dimensions have gradually increased, the maxima being those attained by some of the locomotive builders of the present time. The dotted line shows the gradual increase in the dimensions of the high-pressure cylinders of the London & North-Western compound engine.

It may be argued that this is not a fair comparison, as the boiler has to supply steam, not only for the high, but also for the low-pressure cylinders. This is, no doubt, partially true, but only to the extent of the difference in the cut-off between the high-pressure cylinder of a compound engine and the cut-off in the cylinder of a simple engine, which latter, as it uses the steam only once and in a larger cylinder, has an earlier cut-off, in the ordinary working, than is the case with the smaller high-pressure cylinder of a compound engine. It appears, however, to the writer to be fair in this diagram to show only the high-pressure cylinder, which is, after all, the only one receiving its supply of steam direct from the boiler. It may here be mentioned that this longer period of admission into the high pressure cylinder, and the steam being constantly in the cylinder,—not only on the admission side of the piston, but also on the exhaust side, while discharging into the receiver,—has the effect o keeping the walls of the cylinders at a uniform temperature, thus getting the utmost value in both cylinders, out of the gradually expanding steam which is not affected by condensation in the same degree as steam passing through the cylinders of an ordinary high-pressure engine.

The difficulty in Great Britain of building boilers capable of generating and maintaining sufficient steam for cylinders 18 and 20 inches in diameter, when working heavy loads at high speeds, is admitted by every locomotive engineer; and if it can be shown that a compound engine, the boiler of which has to feed only a pair of 15-inch cylinders, can successfully work the heaviest and fastest trains running in Great Britain, it ought to be a very strong argument in favour of the application of the compound principle to locomotive engines. This conclusion also seems to point to the fact that any further development required to meet the ever increasing demands for additional power will have to be on the same lines.

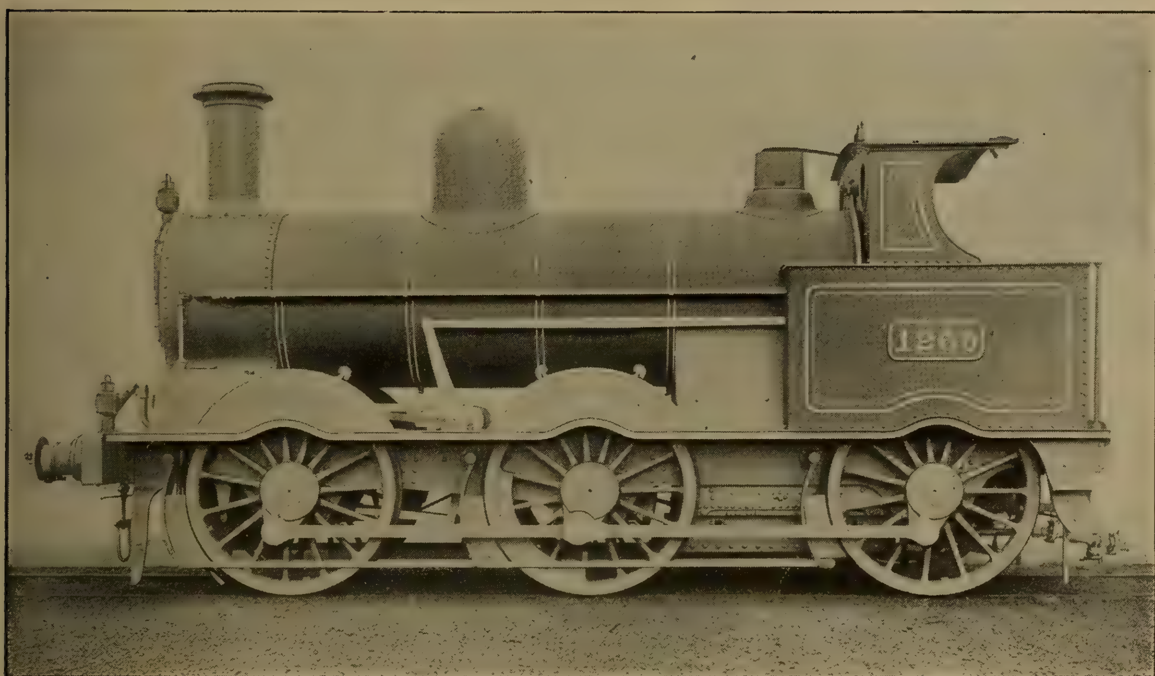


FIG. 6.—WEBB'S SIX-WHEEL COUPLED GOODS ENGINE. LONDON & NORTH-WESTERN RAILWAY

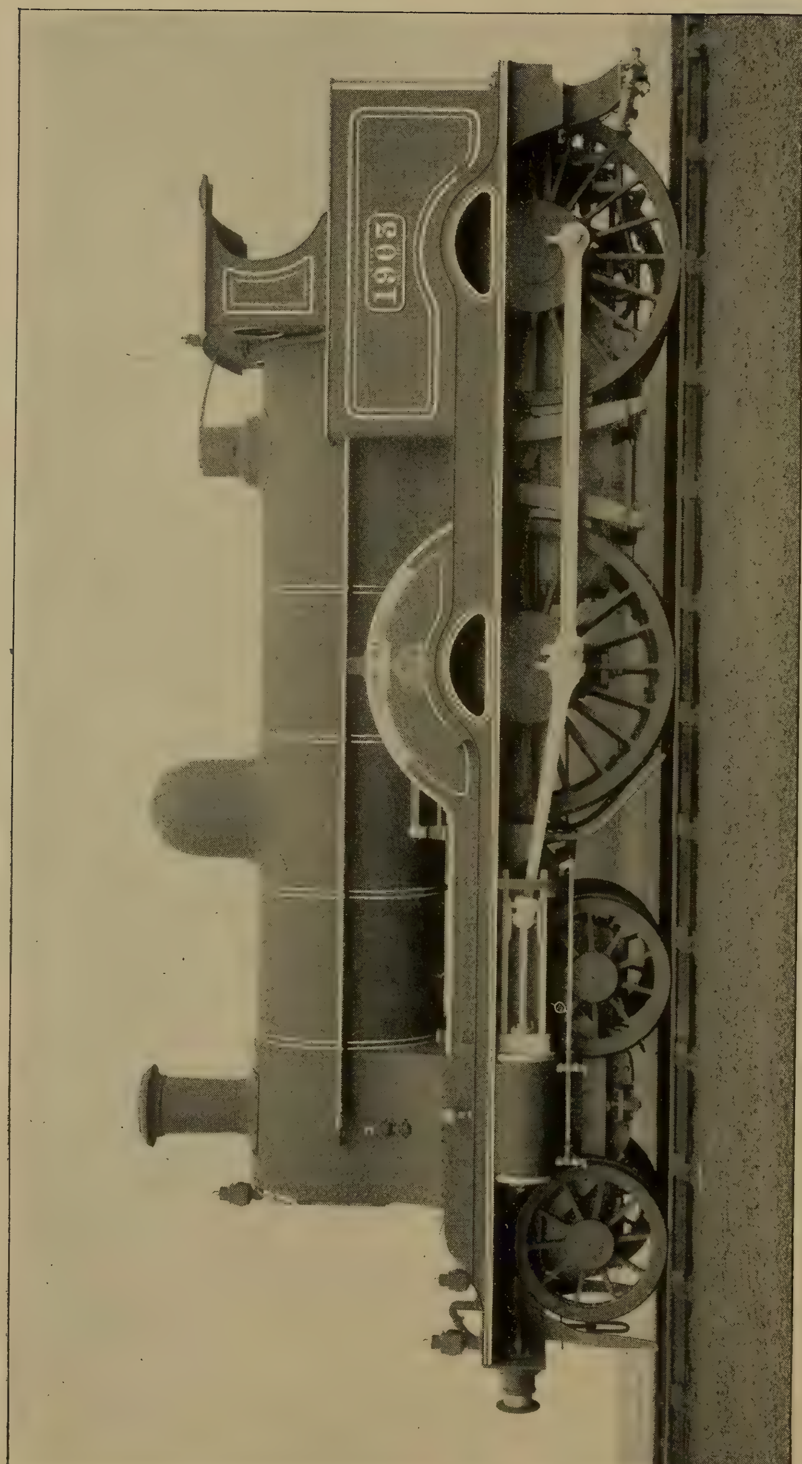


FIG. 7.—WEBB'S LATEST FOUR-CYLINDER COMPOUND ENGINE "IRON DUKE." LONDON & NORTH-WESTERN RAILWAY

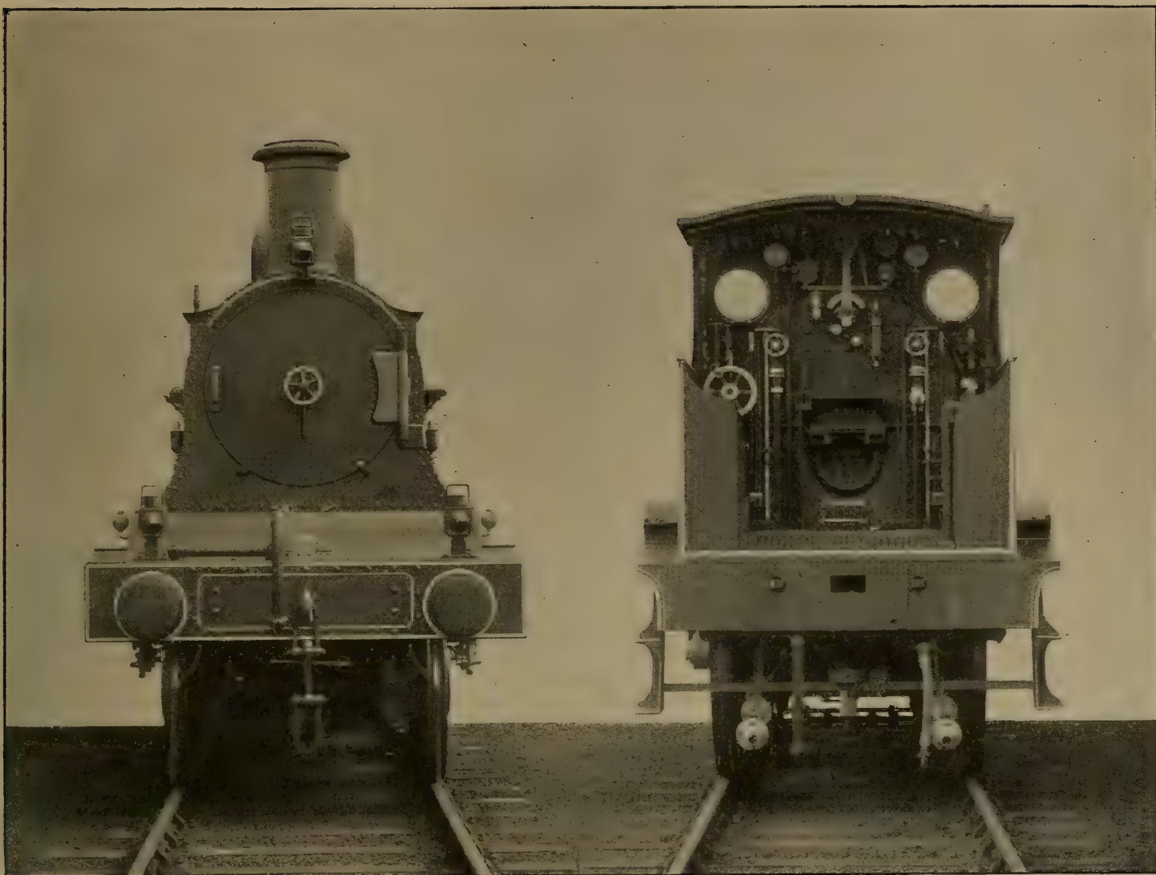


FIG. 8.—FRONT AND REAR VIEWS OF THE "IRON DUKE"

Within the space here available it would be impossible to do more than just touch upon the question of goods engines. Probably the two most powerful types constructed for main line service are Mr. Webb's eight-wheel, coupled, three-cylinder compound engine, and the eight-wheel, coupled engine designed by Mr. Aspinall for the Lancashire and Yorkshire Railway. In the former engine the wheels are 4 feet 3 inches in diameter, all three cylinders are placed in line, and all drive on to the same axle. The high-pressure cylinders are 15 inches in diameter, and the low-pressure cylinder is 30 inches. The heating surface is,—

Fire box	114.7 sq. ft.
Tubes	1374.3 sq. ft.
Grate area	20.5 sq. ft.

The engine weighs, altogether, 49 tons, 5 cwt., exclusive of tender, and the tractive power is 26,682 pounds.

The introduction of these engines on the North-Western system has had the effect of doing away with a large number of banking and assisting engines on the heavy gradients between Crewe and Leeds, and Crewe and Carlisle. On many parts of the main line they are working coal trains, consisting of fifty loaded waggons, equivalent to a gross tonnage of 662 tons, as against thirty-five waggons weighing 463 tons, which is the ordinary maximum load of the six-wheel coupled engine.

As a good example of what can be done by one of these compound coal engines, and to show the power that can be transmitted through the medium of a pair of 15-inch high-pressure cylinders, the following particulars are given of a trial trip made a short time ago with a train of 117 empty waggons and 3 brake vans. From its position in the sidings at Crewe, on a rising gradient of 1 in 150, its great length extending over several reverse curves, Engine No. 1815, of the class illustrated in Fig. 2, started this train, which weighed 630 tons, exclusive of engine and tender, without difficulty, and steadily hauled

FIG. 9.—SPECIAL TRAIN ON THE LONDON & NORTH-WESTERN RAILWAY, CARRYING THE INSTITUTION OF CIVIL ENGINEERS

it up the 10 miles of a rising gradient to Whitmore at an average speed, after getting well under way, of 16½ miles an hour. The total number of revolving axles was 249, and the total running weight, including engine and tender, 705 tons.

Mr. Aspinall's eight-wheel goods engine, shown in Fig. 3, is of the ordinary simple type, with inside cylinders 20 by 26 inches; the wheels are 4 feet in diameter, and the total weight of the engine is 53 tons, 15 cwt., 3 qrs. Like Mr. Aspinall's other engines, it has a very large boiler and heating surface, of which latter the tubes constitute 1877 and the firebox 161.64 superficial feet.

Another powerful eight-wheel, coupled, main line goods engine, by Mr. Wilson Worsdell, is in course of construction at the North-Eastern Railway Locomotive Works, and Mr. Webb has also built 6-wheel, coupled, goods engines (Fig. 6) with 18-inch cylinders and Joy valve gear for fast goods traffic, which have improved upon the work done by the original London & North-Western standard type of six-wheel coupled engines. But with these exceptions, there has been very little to chronicle in the development of the goods engine, which has altered only very slightly in general design since the late Mr. John Ramsbottom built the famous D. X. engines, of which the London & North-Western Railway still possesses upwards of five hundred. The coupled wheels of ordinary standard goods engines are usually about 5 feet in diameter, the cylinders having a diameter of 17 to 18 inches, with a stroke of 24 to 26 inches.

Dealing, now, with the different types of passenger engines, it may be interesting to show, in tabular form, the practice on the principal British railways in the matter of diameter of driving wheels, cylinder capacity, heating sur-

LEADING TYPES OF BRITISH LOCOMOTIVES

	Diameter of Driving Wheels	Diameter of Cylinder. Inches	Stroke of Piston. Inches	Heating Surface. Square Feet	Grate Area. Square Feet	Pressure per Square Inch, Lbs.
COUPLED ENGINES						
London & So. Western	6′ 7″	18″	26″	1500	24	175
Lon., Brighton & So. C'st.	6′ 9″	19″	26″	1650	23	170
Great Central	7′ 0″	18½″	26″	1318	20	170
Great Western	6′ 8″	18″	26″	1520	23	180
Lancashire & Yorkshire	7′ 3″	19″	26″	2052	26	175
London & Nor.-West'n	6′ 6″	17″	24″	1083	17	150
Great Eastern	7′ 0″	19″	26″	1630	21	180
Great Northern	6′ 6″	19″	24″	1442	26	175
Midland	7′ 0″	19″	26″	1261	19	160
North Eastern (6 wheels coupled)	6′ 1″	20″	26″	1766	23	200
North British	6′ 6″	18¼″	26″	1350	20	175
Caledonian	6′ 6″	19″	26″	1540	23	180
SINGLE ENGINES						
Midland	7′ 9″	19½″	26″	1217	24	180
Great Northern	8′ 0″	18″	28″	1045	23	170
COMPOUND ENGINES						
London & North Western—						
3 cylinders, 2 H. P.	7′ 1″	14″	24″	1401	20	175
1 L. P.	7′ 1″	30″	24″			
4 cylinders, 2 H. P.	7′ 1″	15″	24″	1379	20	200
2 L. P.	7′ 1″	20½″	24″			
AMERICAN PRACTICE						
Chicago & Nor.-West'n	6′ 8″	20″	26″	3015	42	200
Lake Shore Railroad— Mogul type, 6 wheels coupled	6′ 8″	20″	28″	2917	34	210
Pennsylvania Railroad— Atlantic type, Wide firebox	6′ 8″	20½″	26″	2320	69	185

face, grate area, and steam pressure. These data are therefore given in the table on the opposite page.

In order to emphasise the points of comparison and difference to which reference has been made, similar information is given with respect to three types of American locomotives, all of which have a heating surface of over 2000 square feet. In one case the boiler pressure reaches 210 pounds per square inch, whilst the heating surface is nearly 3000 square feet, and the grate area is 34 square feet. This obviously gives the American boiler an enormous reserve power, such as it is impossible to obtain in British boiler construction.

In the limited space of such an article as this it is not possible to illustrate or comment upon the principal types of locomotives running on all British railways. The writer, therefore, proposes more particularly to exemplify those built by several well-known engineers of to-day who have made a specialty of certain phases of locomotive engineering, and have in many cases introduced important developments with which their names will always be associated. Whatever surprises in locomotive development may be in store for us and our descendants, Mr. Webb will always be remembered as the inaugurator of a new epoch in locomotive construction at the end of the nineteenth century. It was only in 1880 that he started

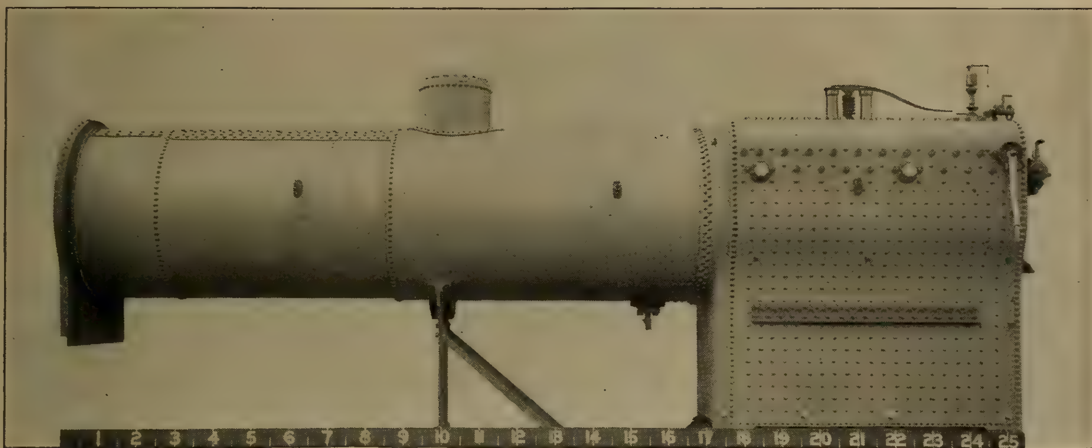


FIG. 10.—BELPAIRE BOILER USED ON THE LANCASHIRE & YORKSHIRE RAILWAY

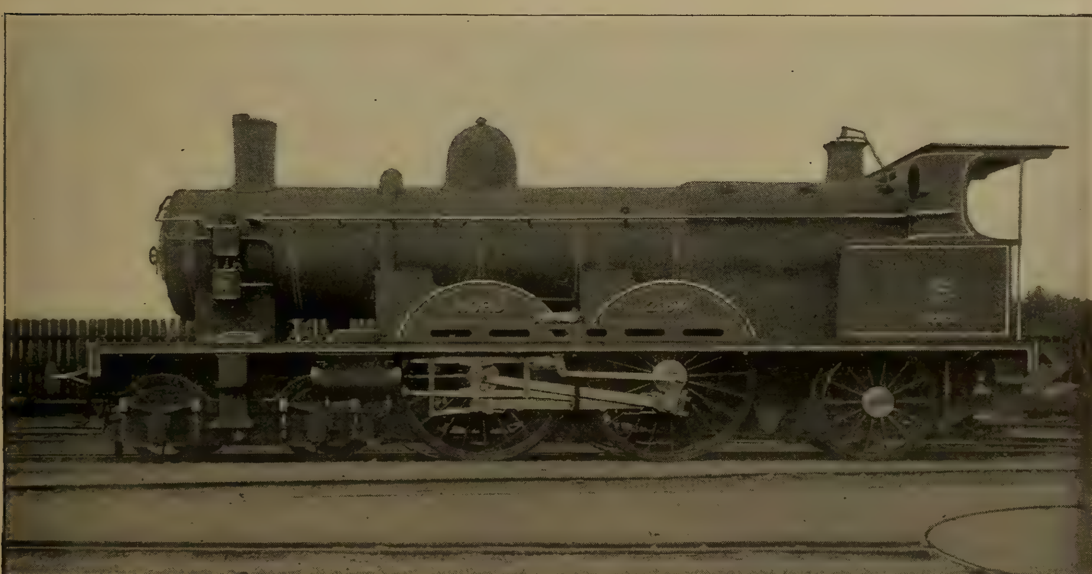


FIG. 11.—COMPOUND ENGINE ON THE CHEMIN DE FER DU NORD, FRANCE

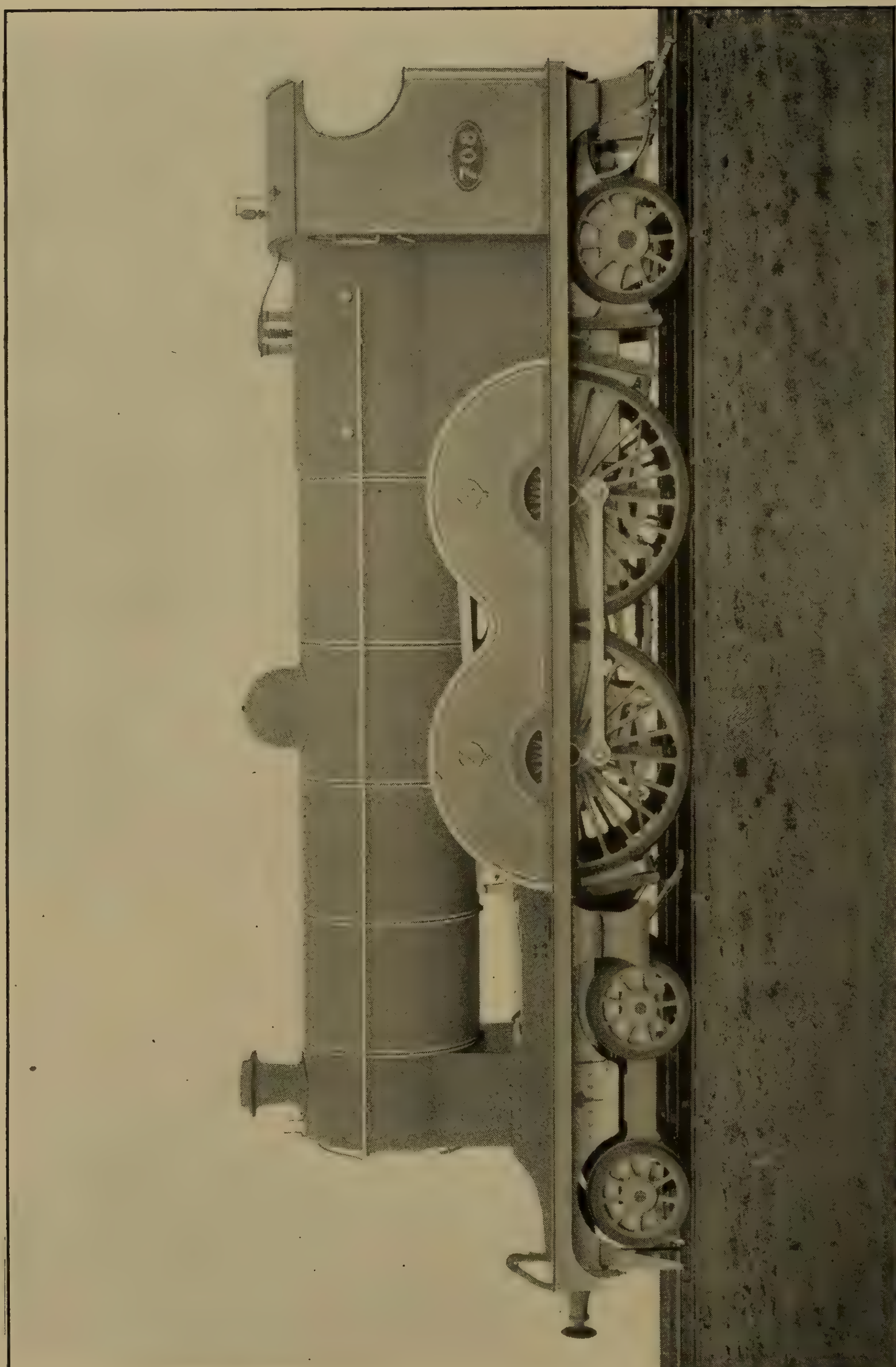


FIG. 12.—ASPINALL'S EXPRESS PASSENGER ENGINE ON THE LANCASHIRE & YORKSHIRE RAILWAY

building compound locomotives, and while he has perfected and developed the system in Great Britain, he has had few followers among contemporary British engineers. On the Continent, on the other hand, and in other parts of the world, locomotive engineers have recognised the advantages to be gained by adopting his principle.

It was in connection with his work that Mr. C. Rouse Marten, an impartial observer and well-known critic on locomotive performances, at a recent meeting of the Society of Engineers, London, said:—

"Mr. Francis William Webb, mechanical engineer-in-chief of the London & North-Western Railway, may fairly claim to be the introducer of the compound system into the practical politics of locomotive designing and construction. That locomotive compounding had previously been the subject of various desultory and sporadic experiments by Monsieur Mallet and other engineers does not affect this fact. When Mr. Webb placed his engine, 'Experiment' No. 66, on the London & North-Western metals in the year 1882, he virtually inaugurated a new era in locomotive engineering."

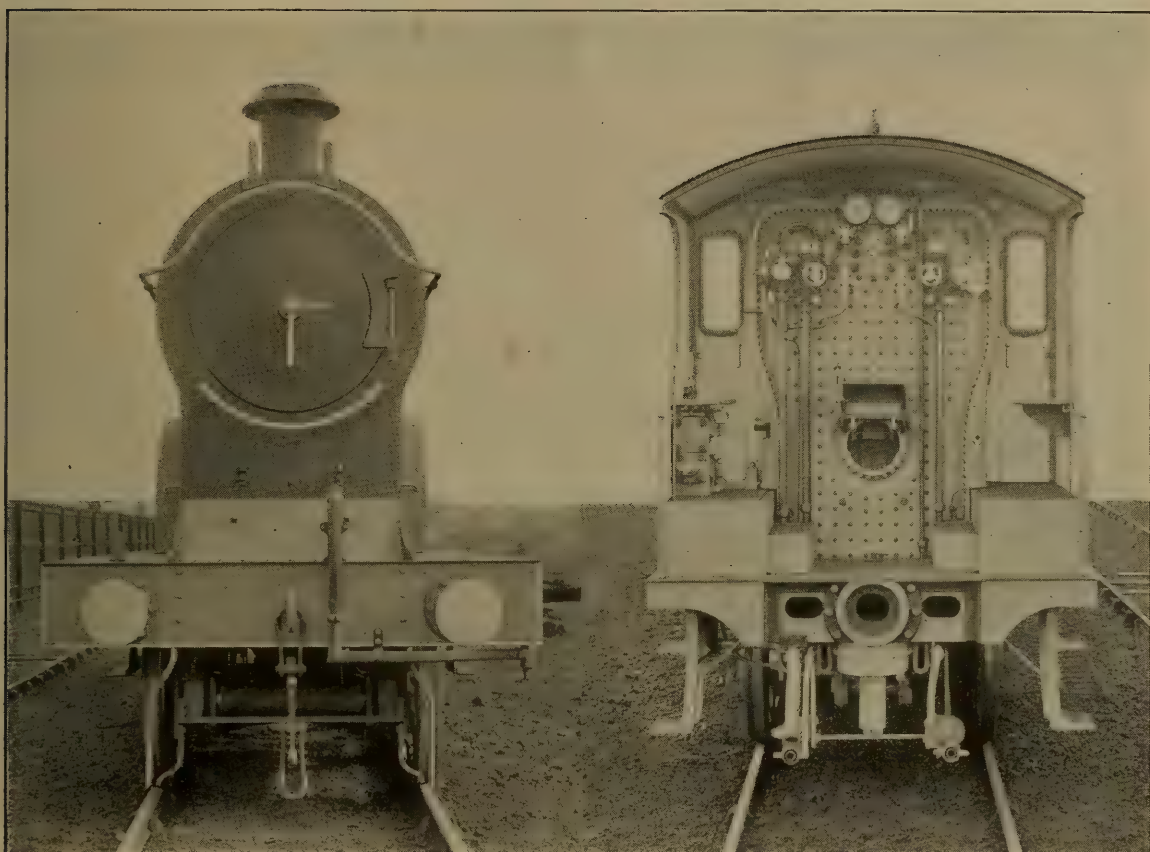


FIG. 13.—FRONT AND REAR VIEW OF ASPINALL'S EXPRESS ENGINE

At the Paris Exhibition, where there were specimens of every up-to-date improvement in applied science, there were exhibited altogether forty-eight typical main line passenger and goods locomotives. Of these forty-eight, only fourteen were not compound engines. Of the simple engines, three were strictly British exhibits; one was a Baldwin goods engine for the Great Northern Railway Company; two were designed by Mr. McIntosh for the Belgian State Railway, and one was built by Messrs. Neilson, of Glasgow, for the Niederländische Railway. Seven of the fourteen were, therefore, of distinctly British origin, which shows that a large majority of locomotive engineers outside

FIG. 14.—IVATT'S EXPRESS PASSENGER ENGINE. GREAT NORTHERN RAILWAY

FIG. 15.—WORSDELL'S SIX-WHEELED PASSENGER ENGINE. NORTH-EASTERN RAILWAY

of Great Britain are in favour of the compound principle.

It is an undoubted fact that the Webb four-cylinder compounds are working the heaviest and fastest passenger trains in Great Britain, whilst the Glehn four-cylinder compound engines on the Chemin de Fer du Nord, in France, are working the heaviest and fastest express passenger trains running on Continental roads. In the United States the Atlantic type of four-cylinder compounds are hauling the fastest express trains in the world between Philadelphia and Atlantic City, although it should be borne in mind that these trains, while timed faster than any in Great Britain, cannot come up to British trains in point of weight,—a very important factor in its relation to high speeds.

An illustration of the latest type of four-cylinder, compound locomotives working the fastest trains on the European Continent, on the Chemin de Fer du Nord, is given in Fig. 11, as affording some sort of standard of comparison with British locomotives.

This article can pretend to deal only very briefly with a few of the latest types of engines, and it is impossible to

FIG. 16.—DRUMMOND'S EXPRESS ENGINE WITH CROSS WATER TUBES. LONDON & SOUTH-WESTERN RAILWAY

FIG. 17.—HOLDEN'S OIL FUEL EXPRESS PASSENGER ENGINE GREAT EASTERN RAILWAY

follow the development of the compound system on the London & North-Western Railway step by step. The three-cylinder engines of the "Jeanie Deans" and "Greater Britain" type have done, and are still doing, excellent work. For many years the former engine, illustrated in Fig. 5, worked daily the 2 P. M. corridor Scotch express train from Euston, returning with the Up-Scotch express, leaving Crewe at 7.38 P. M.

These exceptionally heavy trains were worked most successfully, with absolute punctuality, often making up time lost owing to permanent way and signa slacks. But, as Mr. Ivatt said to the Institution of Civil Engineers recently, "When a locomotive engineer made an engine that was capable of pulling a church, he was asked to hitch on the schools as well." With the general introduction of corridor trains and the tendency to increased weight, Mr. Webb has found it necessary to provide engines of even greater power than "Jeanie Deans."

Fig. 7 shows his latest four-cylinder, compound express passenger engine, a magnificent specimen of which was

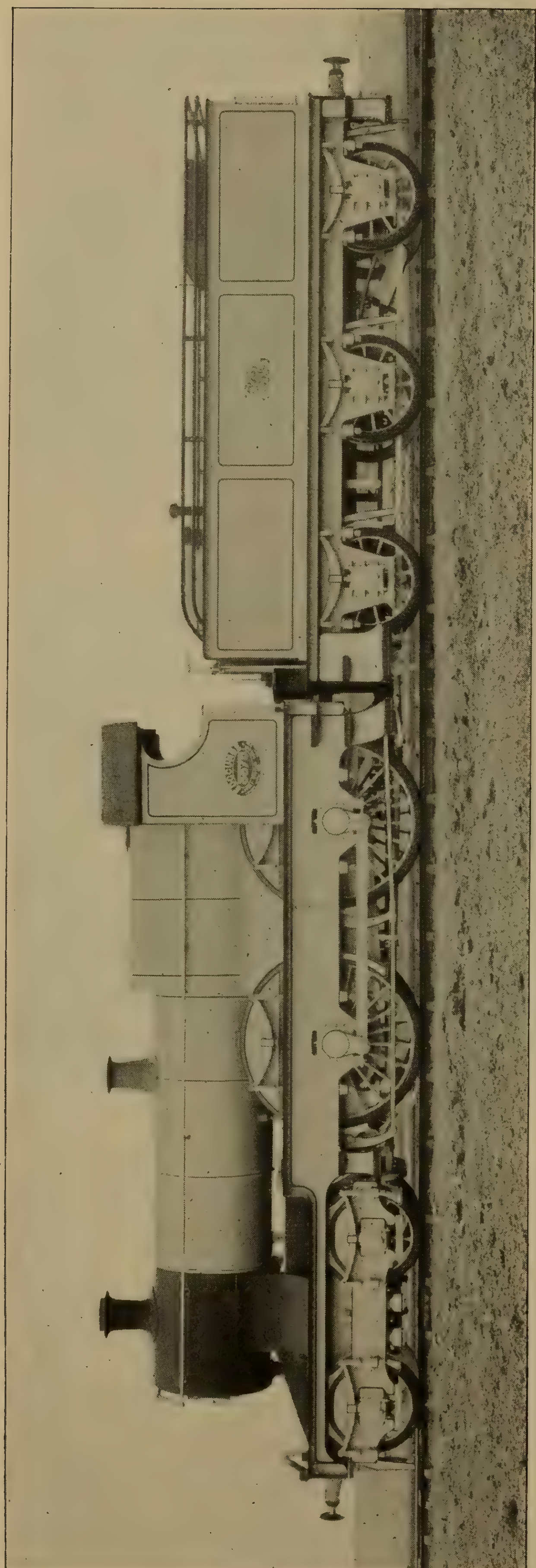


FIG. 18.—DEAN'S "BULLDOG" TYPE. GREAT WESTERN RAILWAY

shown at the Paris Exhibition. A distinctive and much observed feature of this exhibit was that the engine was simply an ordinary example of the sound, business-like work turned out at Crewe, without any superfluous exhibit of embellishment or polish. All the bright parts, connecting-rods, etc., were exactly as turned out by the machine tools without any filing.

The cylinders are placed in line, and all drive on to the axle of the driving wheel, which is coupled to the trailing wheels behind the firebox. The Joy valve gear is applied to the low-pressure cylinders in the usual way, whilst the low-pressure valve spindle is prolonged through the front of the valve chest, and coupled by means of a lever of the first order to the high-pressure valve spindle. Thus, only two sets of valve gear are used for the four valves. The fact that the four cylinders work on the one axle gives a very equal distribution of the strains, whilst the general design of the engine is such as to give ample bearing surfaces in all working parts.

At present forty of these engines are at work, every one of which is "double manned," is in steam six days of every week, and has a minimum of 316 miles cut out for its daily work. It may, therefore, be taken that, while bearing the strain of running this enormous mileage day by day, a mileage which, to the best of the writer's knowledge, is in excess of that expected from any other engines in existence, the North-Western compound engines are daily, without assistance, drawing loads of 333 tons, the whole train, including engine and tender, weighing 414 tons, and running at an average speed of 52 miles an hour. The writer must be pardoned for going more particularly into details

Leading Dimensions of Webb's Four-Cylinder Compound "Iron Duke"

Cylinders—			
2 High pressure	15 in. diam. x 24 in. stroke		
Low pressure	20½ in. diam. x 24 in. stroke		
Wheels—			
Driving and trailing	7 ft. 1 in. diameter		
Radial truck	3 ft. 9 ins.		
Wheel Base—			
Centre of radial truck to centre of driving wheels	10 ft. 4½ ins.		
Centre of driving wheels to centre of trailing wheels	9 ft. 8 ins.		
Total wheel base	23 ft. 2 ins.		
Boiler—			
Mean diameter outside plates	4 ft. 2⅞ ins.		
Length of barrel	10 ft. 11⅝ ins.		
Length of fire-box (outside)	6 ft. 10 ins.		
Width of fire-box (outside)	3 ft. 11 ins.		
Number of tubes	225		
Diameter of tubes (outside)	1⅞ ins.		
Boiler pressure	200 lbs per sq. in.		
Heating Surface—			
Tubes	1220.5 square feet.		
Fire-box	159.1 " "		
Total	1379.6 " "		
Fire grate area	20.5 " "		
Weight of Engine in Working Order—	T	C	Q
Weight on radial truck	18	18	0
" " driving wheels	18	0	0
" " trailing wheels	17	10	0
Total weight	54	8	0
Weight of tender in working order	26	12	0
Total weight of engine and tender in working order	81	0	0

of the running of London & North-Western engines, but whilst they are the engines with which he is most intimately acquainted, they may also be taken as ordinary examples of what is expected from the British express passenger engine of to-day, working over an ordinary track, if indeed the term ordinary can be applied to the splendid permanent way of the London & North-Western Railway.

As an example of what London & North-Western four-cylinder compound engines can do, the following particulars are given of a run from Euston to Crewe with a special train conveying the members of the Institution of Civil Engineers. An illustration of this train is given in Fig. 9.

Particulars of Train

Number of vehicles	14
Weight of train, exclusive of engine and tender	329 tons 5 cwt.
Weight of train, including engine and tender	410 " 5 "
Weight of train, including engine and tender and passengers	420 " 5 "
Total length of train, including engine and tender	716 ft.
Number of axles in train, including engine and tender	62
Ratio of weight of engine and tender to weight of train	1 to 4.18

Particulars of Run, Down Journey

Coal consumed on journey between Euston and Crewe	3 tons 2 cwt.
Consumption of coal in lbs. per mile on journey	43.7
Total quantity of water evaporated (in gallons)	5428.5
Lbs. of water evaporated per lbs. of coal	7.8
Class of coal used on engine	South Wales coal
Maximum pull on draw-bar at starting	4.75 tons
Maximum pull on draw-bar whilst running	5.25 "
Steepest gradient	1 in 70
Maximum speed in miles per hour	71
Average speed in miles per hour	50
Total length of trip	159 miles

A famous train is the London & North-Western corridor train, and the following example of an ordinary run with this may be of interest. On the date in question the weight of the train was 316 tons, 6 cwt., 3 qrs.; total weight of engine and train, 397 tons, 6 cwt., 3 qrs.

		Time	Miles	Speed	Average Speed
Euston	dep.	2.00	----	----	52.5
Willesden	arr.	2.09	5½	36.6	
"	dep.	2.12	----	----	
Harrow	pass.	2.22	11½	36.0	
Watford	"	2.30	17½	45.0	
Boxmoor	"	2.38	24⅜	51.5	
Berkhampsted	"	2.43	27⅞	42.0	
Tring	"	2.47½	31⅝	50.0	
Cheddington	"	2 53	36	47.7	
Leighton	"	2.56½	40⅛	70.7	
Bletchley	"	3.02	46⅝	71.0	
Wolverton	"	3.08	52⅜	57 5	
Roade	"	3.16	59⅞	56.2	
Blisworth	"	3.19	62¾	57.5	
Weedon	"	3.26	69½	58.0	
Welton	"	3 32	75¼	57 5	
Rugby	"	3.40	82½	54 4	

Mr. Aspinall, the late locomotive superintendent, now the general manager, of the Lancashire & Yorkshire Railway, has earned the distinction of having designed the largest engine running on any British railway. Realising the importance of increasing the capacity of the boiler and its heating surface, he constructed a boiler, shown in Fig. 10, of such proportions that the extreme width and height limit possible on a British railway is reached. It has a heating surface of 2052 square feet, with a grate area of 26.05 square feet. The firebox is of the Belpaire type. The flat top of the firebox shell enables it to be stayed directly to the top of the copper firebox, which gives increased steaming space, is better adapted for cleaning purposes, and dispenses with roof bars. The outside diameter of the barrel is 4 feet 10 inches, and the length is 17 feet

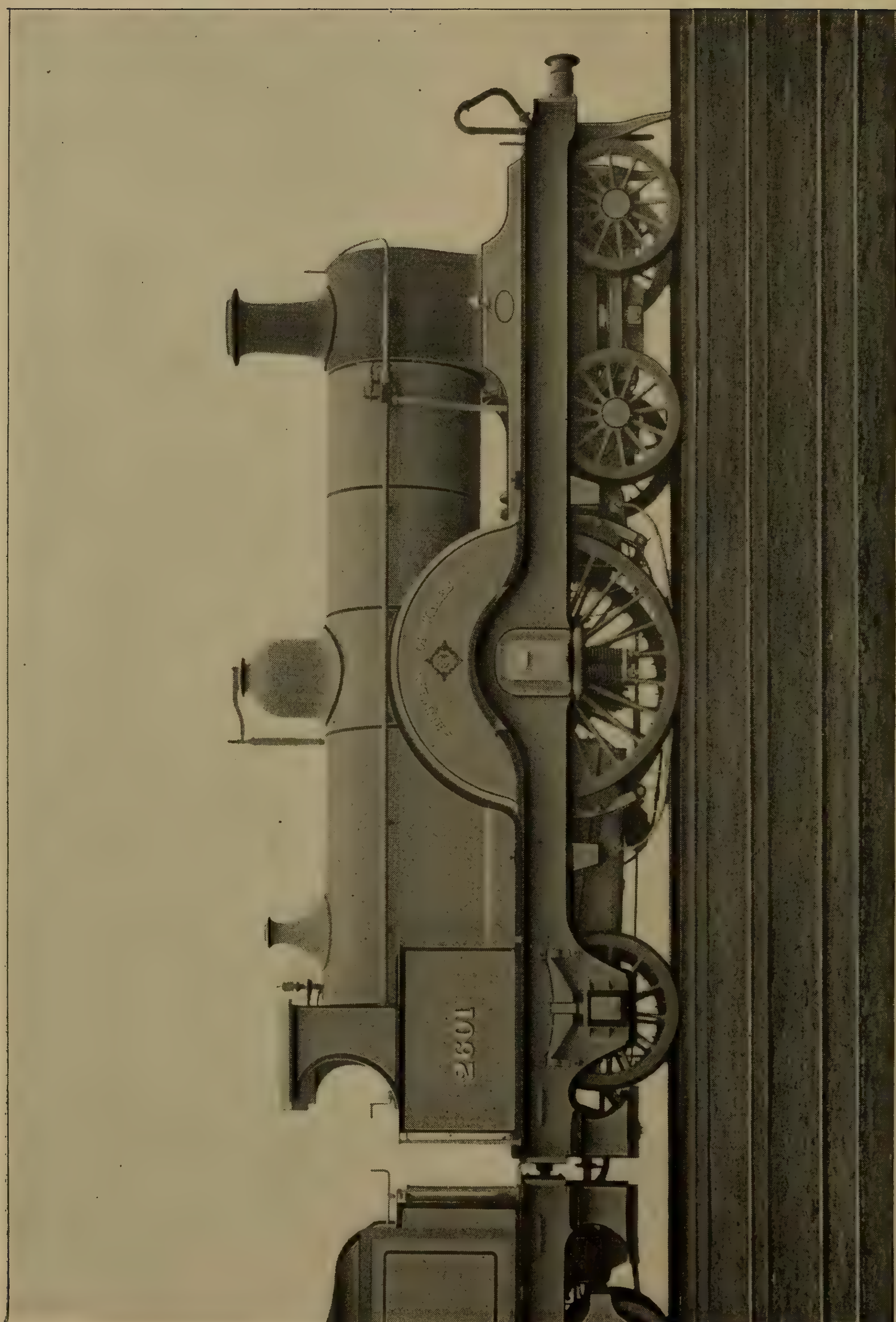


FIG. 19.—JOHNSON'S SINGLE-WHEEL EXPRESS ENGINE. MIDLAND RAILWAY

1⅜ inches. The centre of the barrel is 8 feet 11 inches above the rail level. There are 239 steel tubes, 15 feet long by 2 inches outside diameter, and the pressure carried is 175 pounds per square inch.

The engine shown in Fig. 12 has ten wheels, four coupled driving wheels 7 feet 3 inches in diameter, and a leading bogie, as well as a pair of carrying wheels, behind the firebox. The total weight is 58 tons, 15 cwt. The illustrations have been kindly supplied by Mr. H. A. Hoy, the present locomotive superintendent of the Lancashire & Yorkshire Railway.

The late Mr. Patrick Stirling made himself and the Great Northern Railway famous by the 8-foot single engine, with outside cylinders 18 by 28 inches, which made such splendid runs on the East Coast route to Scotland. But notwithstanding the increased weight of trains since Mr. Stirling's time, the reputation of the line for fast and punctual running is not likely to suffer under his successor, Mr. Henry A. Ivatt, whose latest passenger engine is shown in Fig. 14. Mr. Ivatt realises that single-wheeled engines are not reliable for working very heavy trains. There have been, and there still are, frequent instances of meritorious performances at high speeds with heavy trains by Great Northern single engines, and in the majority of cases these engines are able to give a good account of themselves; but a good run one day may be followed by a fiasco the next, as a slippery rail is a fatal enemy to the single-wheeler, often causing great loss of time. Indeed, single engines are not infrequently brought to a dead stand through slipping, when working up an incline, even with trains of very moderate weight.

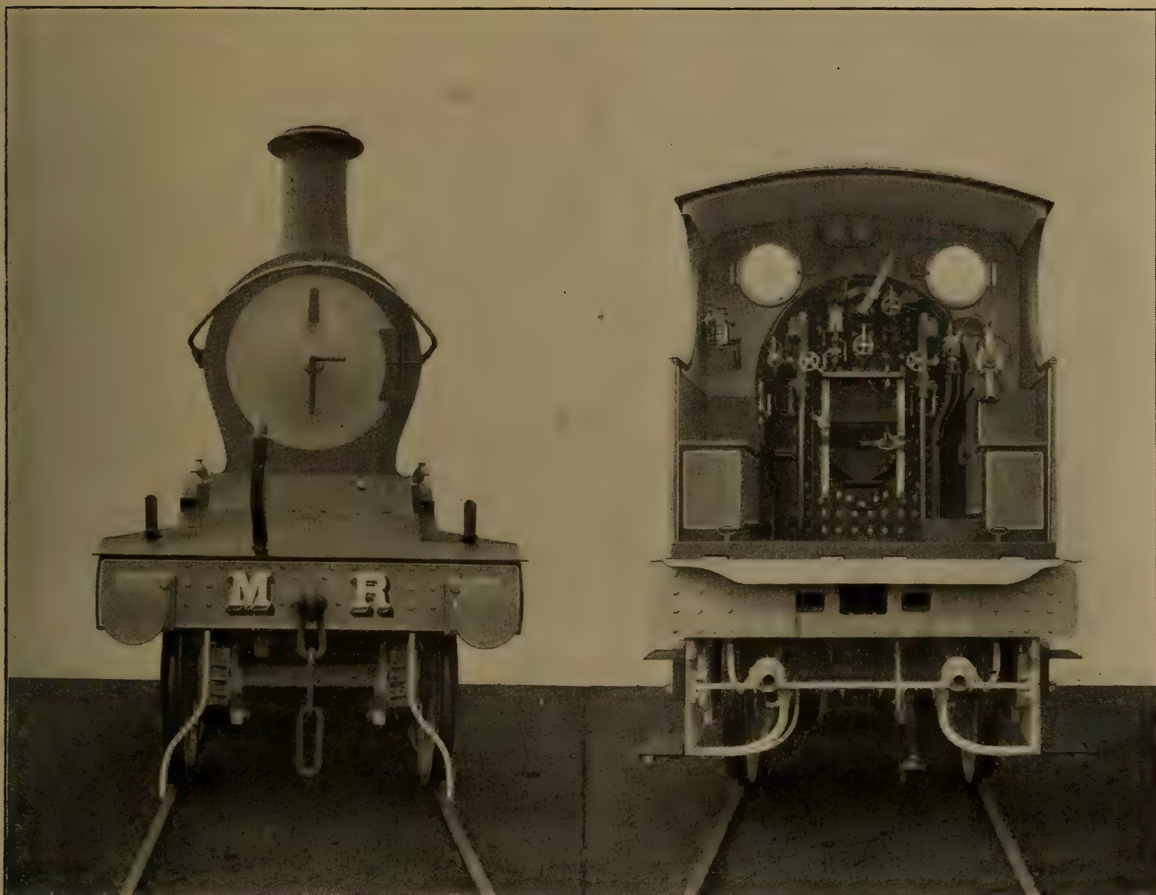


FIG. 20.—FRONT AND REAR VIEWS

Mr. Ivatt has, therefore, built for the Great Northern Railway a powerful engine with 19-inch cylinders, 6-foot

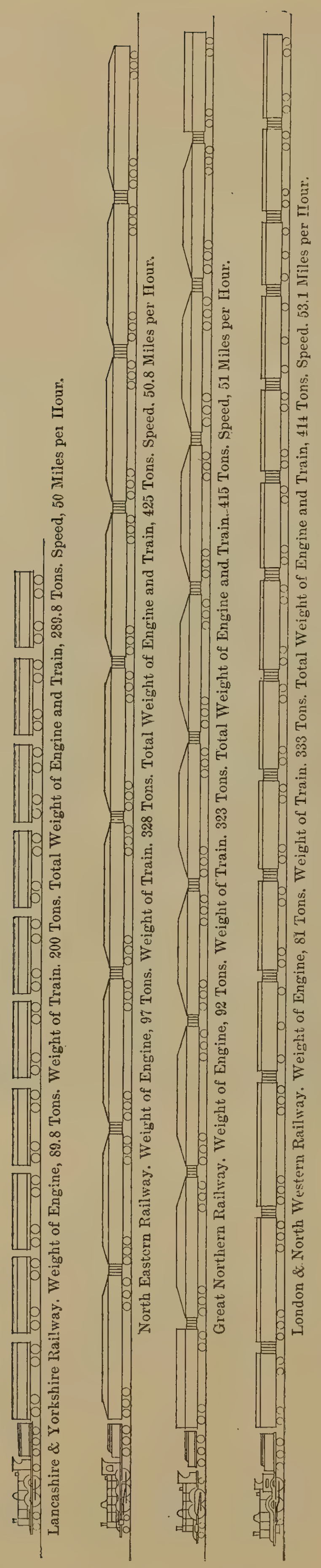


FIG. 21.—COMPARATIVE WEIGHTS OF BRITISH RAILWAY TRAINS

6-inch coupled driving wheels, and a boiler of larger dimensions than those constructed by his predecessor. The outside diameter of the barrel is 4 feet 8 inches, the length 14 feet 8 inches, and the steam pressure carried is 175 pounds per square inch; the grate area is 26¾ square feet, and the heating surface, 1442 square feet. Mr. Ivatt is very strong on the question of keeping down the piston speed as far as possible, and in his new 58-ton engines the length of stroke never exceeds 24 inches. The leading end is carried on a four-wheeled bogie, and there is a small pair of carrying wheels behind the firebox. The following are some good examples of the work done by Mr. Ivatt's engines on the Great Northern Railway:—

Train	From	To	Miles	Mins.	Speed miles per hour	Weight of train Tons.
10.00 A.M.	Kings Cross	Grantham	105	114	55.2	249
2.20 P.M.	Kings Cross	York	185	218	51.7	236½
5.45 P.M.	Kings Cross	Peterboro.	76	90	52 8	280
2.35 P.M.	York	Grantham	83	97	51.3	235
10.54 A.M.	Doncaster	Peterboro				
	Doncaster	Grantham	50	58	51.7	250
	Grantham	Peterboro.	29	33	54.3	272
2.45 P.M.	York to Newark					
	York	Doncaster	33	38	52.1	362
	Doncaster	Newark	35	40	52.5	340

Mr. Wilson Worsdell has, during his tenure of office on the North-Eastern Railway, always been noted for the very powerful and heavy engines he has built, and he has made an important innovation in British practice by designing the six-wheel coupled engine, shown in Fig. 15, for making long runs with heavy express passenger trains. These engines work in conjunction with Mr. Ivatt's on the East Coast route between London and Scotland. The following are the leading particulars of the North-Eastern engine:—

Boiler	Outside diameter	4' 9"
	Centre of boiler from rail.	8' 2"
	Length of Barrel	15' 0"
	Pressure	200 lbs. per sq. in.
Tubes	Number	204
Steel	Length	15' 4⅓"
	Outside diameter	2"
	Grate area	23 square feet
	Heating surface	1766.86 square feet
Cylinders		20" diameter, 26" stroke
Driving wheels		6' 1¼"
Weight		62 tons, 8 cwts.

Mr. James Holden is an engineer who keeps well ahead of the work expected

PERFORMANCES OF MODERN BRITISH LOCOMOTIVES

Railway	Train: Time	Train: From	Train: To	Distance Miles	Time Mins.	Speed M. P. H.	Weight: Train Tons	Weight: Engines Tons	Weight: Total Tons	Principal Rising Gradients
London & South-Western	9 40 A. M.	Waterloo	Southampton	79	98	48.4	288	89	377	6 miles 1 in 249. 10 miles 1 in 298. 10 miles 1 in 388
North-Eastern	1.55 P. M.	York	Newcastle	80½	95	50.8	328 Including Passengers and luggage	97	425	Long steady pull chiefly up hill for about 50 miles from York, but no long heavy gradients
London & North-Western	9 51 P. M.	Rugby	Crewe	75¼	85	53.1	333	81	414	Ruling gradient 1 in 330. Long pull up to Whitmore from Stafford
Midland	2.10 P. M.	London	Nottingham	123½	143	51.8	177 Including Passengers	99	276	4¾ miles 1 in 176. 4¾ miles 1 in 166. 3½ miles 1 in 119. 2 in 1,8.5
Lancashire & Yorkshire	Express	Leeds	Liverpool	85	102	50.0	200	89.8	...	The gradients on this line are very heavy. 1 in 50 out of Leeds Station. 1 in 77 out of Manchester, and there are several gradients of 1 in 90 that have to be traversed
Great Northern	2.45 P. M.	York	Newark	68	80	51.0	323	92	415	Engines working this train have made several very good runs making up time

from engines running on the Great Eastern Railway, and his latest engine, shown in Fig. 17, is a very fine specimen of a modern British express locomotive with 7-foot coupled wheels and 19 by 26-inch cylinders. It has earned special distinction for its designer in that it is the outcome of his enterprise in inaugurating the use of liquid fuel for British locomotives. The liquid fuel, carried on the tender in a tank of 500 gallons capacity, is led by pipes to two ejectors, placed in orifices in the firebox plates immediately below the footplate, and 12 inches above the firebars on which a small layer of broken firebricks is spread. The ejectors are so constructed that they distribute the liquid fuel in the form of a spray into the firebox, and at the same time drive into it a supply of heated air, thus tending to economy of fuel and perfect combustion.

Mr. Holden supplements the liquid fuel system by a small coal fire, by means of which the temperature of the firebox can be kept more even, and the plates are not subjected to sudden cooling when the oil sprays are shut off. The oil tanks can be readily removed from the tenders, thus converting them into ordinary coal-carrying tenders, if desired. Compressed air from the Westinghouse brake is used on these engines to actuate the reversing gear.

Fig. 16 shows the most recent passenger engine built by Mr. Drummond for the London and South-Western Railway. The prominent feature of this is the introduction of cross water tubes to increase the firebox heating surface. There are sixty-one of these tubes, 2½ inches in diameter, with a total heating surface of 165 square feet. The sides and crown of the firebox represent a heating surface of 148 square feet, so that the addition of the water tubes more than doubles the heating surface of the firebox.

The engine is fitted also with a steam reversing gear, with a cataract on the left-hand side of the engine. Mr. Stirling, the late locomotive superintendent of the South-Eastern Railway, was the first to introduce a steam reversing gear for locomotives in Great Britain, and,

from the driver's point of view, it is an excellent innovation, saving him a great deal of manual labour, particularly when the usual D-shaped slide valves are used. Increased modern boiler pressures, acting on the backs of the valves, cause the reversing gear to work more stiffly than when lower steam pressures were used. The increased weight on the valves, which can be renewed, not only causes these to quickly wear away, but, what is a more serious matter, causes the port faces to cut, unless carefully watched. For this reason many locomotive engineers are using piston valves, thus doing away with the pressure and undue friction on the valve faces and port surfaces. The London and North-Western Railway four-cylinder compound has a pair of piston valves, admitting the steam to the high-pressure cylinder. These give every satisfaction.

Mr. William Dean's latest and most powerful engine, built for the Great Western Railway, is illustrated in Fig. 18. In this a large heating surface and steam space are obtained by using a very large firebox, the shell of which is considerably higher and generally larger in diameter than the barrel of the boiler. The wheels are 6 feet 8 inches in diameter, and the leading end is carried on a bogie with 4-foot 1½-inch wheels.

The engine has double frames, with outside cranks connected to the coupling rods. The particular class under consideration is called the "Bulldog" type, a name very accurately describing the appearance of the engine, which, with four coupled wheels, having the moderate diameter of 6 feet 8 inches, looks strong enough to haul anything, from an express passenger to a heavy goods train, over the heavy gradients in which the Great Western line abounds.

Mr. S. W. Johnson has not departed from any of the approved canons of locomotive construction in this country. Fig. 19 shows an ordinary single-wheel bogie engine with inside cylinders, but it is a splendid specimen of symmetrical British design and first-class workmanship, and the engine of this class, the "Princess of Wales," exhibited at Paris, was universally admired. It has 19½ by 26-inch cylinders, 7-foot 9½-inch driving wheels, and carries a working pressure of 180 pounds per square inch. The heating surface is as follows:—Firebox, 147 square feet; tubes, 1007 square feet; total, 1217 square feet. It is not to be expected that a boiler with these moderate dimensions can supply steam to cylinders of this size to work very heavy passenger trains at high speeds, but the engine is doing the work which it was built to perform in a highly satisfactory manner, and is working trains of 150 to 200 tons at 52 miles an hour.

Before concluding, the writer desires to thank the locomotive superintendents who have supplied him with photographs for the illustrations in this article, and for giving him the information from which the details here presented were compiled. These details have, of necessity, been greatly curtailed, and many excellent examples of British workmanship and design have unavoidably been altogether passed over. But wherever any particular engine has been singled out, it has been on account of some special improvement brought out by the locomotive engineer responsible for its construction.

As a suitable conclusion to an article professing to show what modern British locomotives are expected to do, a short table is given on page 467 summarising their performances. In this table the writer has endeavoured to include such trains as make the best times with the heaviest loads on railways noted for the excellence of the work done by their engines, and Fig. 21 shows the comparative size, weight, and booked speed of certain of these typical express trains.

AMERICAN TRANSCONTINENTAL RAILWAYS

By James Douglas, LL.D., Past President Am. Inst. M. E.

PART II.—THE ATCHISON, TOPEKA AND SANTA FÉ, THE SANTA FÉ PACIFIC, THE GREAT NORTHERN, AND THE CANADIAN PACIFIC RAILWAYS

Part I. Appeared in the March Number

THE ATCHISON, TOPEKA AND SANTA FÉ RAILWAY

THE Atchison and Topeka started as a Kansas prairie-road; but, through its ramifications, it has become the most extensive of all the mountain railroad systems. The mountain section commences at Trinidad, Colorado, where the road has risen upon the plains from 765 feet at Kansas City, to 6000 feet at Trinidad, in a distance of 652 miles. We have seen that on the line of the Union Pacific, about 180 miles to the north, from Omaha to Cheyenne, in a distance of 516 miles an elevation of 6038 feet was attained. At Trinidad, in the midst of a coal field extending to both sides of the Raton range, the ascent of this spur of the Rockies commences, and is completed in twelve miles by a tunnel at an elevation of 7622 feet above the sea. The road now issues on those vast, rolling plains which spread over Northern New Mexico, Texas, and the Indian Territory, and which feed a thousand rivulets that combine to make the Red and Canadian rivers, discharging into the Mississippi, and the Pecos, which helps to swell the lower Rio Grande. The road proceeds south, with the snowy range of the Sangre de Cristo bounding the view to the west. Behind that flows the Rio Grande, and only beyond that again rises the Continental divide. Over it the line does not pass, for, after crossing the plateau for 175 miles, at elevations varying from 5000 to 6600 feet, it mounts the Sangre de Cristo range (here the Glorieta), descends into the valley of the Rio Grande, and follows it for 300 miles to the Mexican frontier town of El Paso.

THE SANTA FÉ PACIFIC, FORMERLY THE ATLANTIC AND PACIFIC RAILROAD

At the old Spanish town of Albuquerque, in New Mexico, a cross-road branches west, which completes the transcontinental character of the Atchison and Topeka. It was built as a section of the St. Louis and Pacific, which is itself a survival of the old Missouri road, of which I spoke in the historical sketch. It runs for all the distance between Albuquerque, on the Rio Grande, and the Colorado River, at the Needles, through the most mountainous section of New Mexico and Arizona, at a very high average altitude. The Continental divide is passed near Coolidge, at an elevation of 7257 feet, and the road subsequently runs among heavily pine-clad ranges, past the foot of the San Francisco Mountains, parallel with, and at one spot not more than twenty miles south of, the Grand Cañon of the Colorado, and over the southern extension of the Great Basin. The Colorado River crossed, the road traverses the same dreary waste which in the south we knew as the Yuma desert, and in the north as the Humboldt desert, ere it joins the Southern Pacific at Mojave Station. The Southern California, which branches south from the main line at Barstow, crosses the San Bernardino range into the fertile San Gabriel valley, and completes the con-

ANIMAS CAÑON, ONE OF THE MOST PICTURESQUE GORGES IN THE ROCKY MOUNTAINS

nection of the Santa Fé system with the Pacific at Los Angeles and San Diego.

THE NORTHERN PACIFIC RAILROAD

We have seen that a Northern Pacific railroad was the first proposed, but almost the last built, of the first group of transcontinental roads. As now constructed, its eastern terminus is at St. Paul. Thence it sweeps for 275 miles over the rich prairies of Minnesota, then spans the Red River of the North, pursues its way due west still through the most fertile farm-land, crosses the Missouri at Bismarck, and sweeps onward again over deep, rich, black soil, a total distance of about 586 miles from its starting-point, till the Bad Lands of Dakota are reached near the Montana boundary. There it crosses the curve of average rainfall which defines the farming-lands that can be cultivated without irrigation. This curve sweeps northward across the Canadian frontier; but the road stretches westward with the foothills of the Rockies. Yet throughout the whole mountain zone in this parallel the climate is sufficiently humid in average years to clothe the hill-sides everywhere with nutritive grass, and to fill the valleys with perennial streams,—whence the enormous cattle-ranching capacity of Montana through its entire width of 800 miles.

The Bad Lands are a relief to the traveller, wearied by his long journey over these hundreds of miles of prairie. That these prairies have been laid out into immense farms, and are cultivated by machinery, does not increase their picturesqueness, while it deprives them of that human interest with which we invest the homesteads of families who are trying to deserve a living from the earth, and to return her kindness by adorning her, in their humble way, with trees, and fruits, and flowers.

The Bad Lands, which the railway guide-books, unwilling to describe this narrow strip of twenty miles as unfit for occupation, ingeniously say were so called by the early French trappers because they were *terres mauvaises à traverser*, not *à cultiver*, owe their character, probably, to the lignite which once underlay them. Here the outcropping beds have become ignited, and, by the heat thus generated, have altered the colour and character of the adjacent shales and sandstone, rendering them more liable to erosion by water and wind, the combined influence of which has carved the whole country into most fantastic forms. The great eastern buttresses of the Rocky Mountains now loom into view; but the road remains on the prairies, skirting the Powder range till it strikes the Yellowstone River at Glendive. To this valley it clings for 340 miles, as far as Livingstone, where this most important of the northern affluents of the Missouri comes in from the south, having drawn its waters from the heart of the Rockies, and enhanced the beauties of the Yellowstone Park. This valley, where followed by the railroad, is narrow, not averaging three miles in width, and enclosed by bluffs sparsely clad with pine, which, though low, are still high enough to shut out all but glimpses of the Big Horn and Yellowstone ranges to the south, which have deflected the river from a straight course between its source and discharge. But each of the rivers which flow into it from the south, fed by the great spurs of the main range, the Powder River, the Tongue, the Rosebud, and the Big Horn, remind us of the last desperate struggle of the dominant nation of the north, the Sioux, against the march of the white man between 1872 and 1877, hastened by the progress of this very railway,—a struggle rendered memorable by the daring deeds and untimely end of Custer. In this valley also is a memento of Clark, who, on his return journey in 1806, carved his name on a prominent rock and called it Pompey's Pillar,—a name retained for the neighbouring railway station.

From St. Paul to Livingstone the grade has been easy and the elevation low. But the road, after leaving the Yellowstone, commences to climb the Bozeman range, a spur of the Rocky Mountains. It cuts off the summit by a tunnel, at an elevation of 5565 feet, and emerges in a wild gorge, which it follows along the stream of the Gallatin

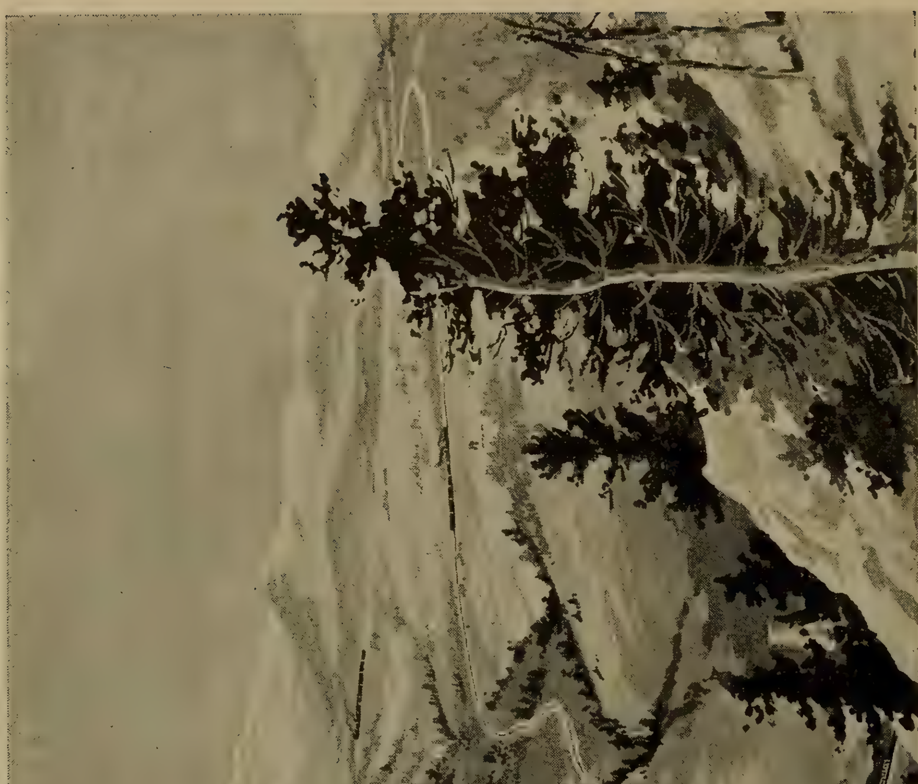
CATHEDRAL SPIRE, ON THE RIO GRANDE SOUTHERN LINE

to the base of the range. Here it enters the birthplace of the Missouri, an amphitheatre of great hills where the Gallatin, the Madison, and the Jefferson unite their waters to form this mighty transcontinental river, which thus springs into existence as a stream of considerable size. We follow its banks for thirty miles, till the Rocky Mountains bar the river's further progress westward. It is prevented, however, from reaching by a straight course its destination in the eastern sea by the confused mass of the Little Belt Mountains, round which it sweeps through Clark's Gate of the Rockies, due north, over the falls of the Missouri, and thence, as a navigable river, eastward. The road, after leaving the river, pursues its way westward, crossing the Continental divide through the Mullen tunnel, at an elevation of only 5648 feet.

We are now in the golden land, and almost every valley has been turned over and over in search of the precious dust. The beautiful town of Helena, near the foot of the divide, stands in a wilderness of boulders, heaps and trenches, and the surface of the valleys near Butte, Bannock, and Virginia City, and many another spot, looks like the Bad Lands of Dakota in miniature, tossed out of all shape by the myriads of miners who, from 1861, when gold was first discovered in Deer Lodge county, till recently, have extracted from the shallow placers of this section of Montana over one hundred millions of dollars. But little is left in this accessible condition; and what little there is will probably remain unmolested, as the Montana miners have ordered away the Chinese.

The Rocky Mountains here, though not of the majestic proportions of the Colorado range, rise high both north and south of the Mullen pass. Along this parallel the range seems to have been, as it were, spliced, the Bitter Root Mountains from the south overlapping on the west the main ridge, which descends from the north. The engineers of the road took advantage of the point where the mass of the range, being thus divided, was reduced in height and a passage was made easy. Tortuously the road ascends the eastern slope of the Continental divide from Helena at 3980 feet to the tunnel, affording a magnificent glimpse of the mountains to the south, which enclose the National Park; but the western descent is less rapid into the valley which carries towards the Columbia the waters of the Deer Lodge creek, *alias* Hellgate River (the former the name in the farming section of its course, the latter in the mining). The mountains close in,—the Bitter Root Mountains on the left, the main ridge on the right,—till the valley is contracted into a gorge, rendered more sombre by the heavy growth of pines which clothe the rocks; for, now that we have crossed the mountains, both plain and hill are forest-clad. Northwest the road runs along the banks of the streams, now swollen into the Clark's fork of the Columbia, unable to escape westward over the high Bitter Root range,—bitter, indeed, to the thousands of penniless prospectors who flocked thither, even from the warm southern territories and Mexico, to seek for but not to gather gold in its snow-clad Cœur d'Alène mines during the rush of 1882. Where Clark's fork expands into the beautiful lake of Pend d'Oreille the road finds egress from the mountains and enters the northern extension of the great plateau, which we have traversed in Arizona, and again when crossing the Great Basin on the Union and Central roads. Only here, as the Rocky Mountains point northwest and the Sierra Nevada and their extension, the Cascade Mountains, have a slightly northeasterly trend, the great valley has been crushed in, almost to extinction. It is at this point only 100 miles across, and at less than 100 miles further to the north it ceases to be a well-defined feature of the continent. There the Rocky Mountains and the Cascades are built together into one broad wall, supporting an elevated plateau, against which the waters of the Pacific beat to the furthest limit of the continent.

But though the Great Basin has shrunk to such meagre proportions, its



MOUNT OURAY, EAST SLOPE OF MARSHALL PASS

contents have grown in value. We are far north, but the warm ocean current, flowing from Japan, carries heat and moisture to the coast, and thus the climate of this section of the State of Washington, even east of the Cascades, so assists the fertility of its soil that the productiveness of this extreme end of the Great Basin almost defies belief. The road cuts diagonally across the basin from the northeast to the southwest, through Spokane, till it strikes the Columbia at Pasco and Ainsworth. From Pasco it continues to cross the basin in a northwest direction, and then ascends the Cascade range to the Stampede pass, at an elevation of 3980 feet. It descends rapidly to its termini at Tacoma and Seattle, on Puget Sound.

The Oregon Railroad and Navigation Company supplies the direct route through Spokane to Portland via Umatilla, where it unites with the road from Huntingdon, and the Oregon Short Line. Pasco, on the Northern Pacific, and Umatilla, on the Oregon Railroad and Navigation Company's line, are near the great bend of the Columbia, where it turns to break through the Cascade range.

The gorge which this magnificent river has cut through these mountains, —the representatives of the Sierra Nevada,—for a distance of over 200 miles, was taken advantage of by the railroad builders to make their escape to the sea. The engineering difficulties in the construction of the road in this section were excessive, for so precipitously do the banks rise out of the water below the Dalles that the road-bed had, in places, to be carved out of the rocky escarpment. The old Oregon trail reached the Pacific by this route, but the obstacles to road-building were so great that the emigrants never attempted to force a passage by waggon below the Cascades. The railway was the first road of any kind on the banks of this stretch of the lower Columbia. The Cascades here soar into magnificent proportions, a number of peaks rising above the snow-line, such as Rainier (Tacoma), 14,860 feet, and Mt. Hood, 11,025 feet.

Portland is on the Willamette River, a large stream which flows from south to north down the coast valley, and joins the Columbia at the bend, where it turns northward to seek an outlet through the Coast range. Here, again, we have found all the topographical elements which combine to shape the western half of our continent. They also appear in the surveys of the most northerly of the United States roads, the Great Northern, but they are no longer recognisable in the profile of the Canadian Pacific.

THE GREAT NORTHERN RAILWAY

The Great Northern Railway, like the Southern Pacific, has grown to its present important position by normal expansion from a local to a transcontinental road; and, like the Southern Pacific, it owes its rapid construction and successful management to individual enterprise and high technical skill.

The Great Northern is the descendant of the St. Paul, Minneapolis and Manitoba, a road which was built to tap the Red River of the North. After its reorganisation it was extended through Northern Dakota into Manitoba, while still retaining its original designation. Not till it left the valley of the Missouri and attained the dignity of a transcontinental road did it assume its present more appropriate title.

The road keeps to the north over the level prairies of Minnesota and North Dakota, and enters the valley of the Missouri at Willisden. It follows the river to its junction with its large tributary, the Milk, whose valley it utilises to circumvent the Bear Paw Mountains, rather than follow the Missouri in its great bend to the south.

The main line runs almost due west, after escaping from the obstruction which the mountains oppose to its straight path. At the northwestern corner of the Bear Paw Mountains, at Pacific Junction, the main line originally turned southwest, rejoined the Missouri at Marian, and followed that river to the Great Falls. There it united with the Montana Central, which continued in the Missouri valley to Helena, whence

THE APPROACH TO THE BLACK CAÑON, COLORADO

it crosses the Main divide to reach Butte, Anaconda, and other important mining towns. These lie in an extraordinarily rich valley, between the two forks of the Rockies, the main watershed and the more imposing Bitter Root mountains.

When it was determined to make Puget Sound the terminus, the main line continued west from Pacific Junction. An easy route was discovered through Snake Head Mountains, which alone afforded any engineering difficulties until the main range had to be passed. This is surmounted at Summit (elevation 5202), and it threaded the apparently inextricable labyrinth of hills to the west of the main divide by following the windings of Missoula creek and the Kootenay River, the latter a large, roaring stream, whose banks and enclosing hills are heavily timbered, and which, therefore, bestows on the scenery a charm not possessed by any of the roads to the south. The Great Northern then turns southward towards Spokane and traverses the head of the great valley, here tapering towards its extinction. At Spokane it connects with and controls an important feeder from British Columbia, the Spokane and Northern Railroad. After crossing the Cascade range, at an elevation of 3375 feet, it runs down its western slope to a town of its own creation, Everett, on Puget Sound.

THE CANADIAN PACIFIC RAILROAD

The building of the Canadian Pacific was even more a political necessity than the building of the Union Pacific. It followed as a consequence on the admission of British Columbia to the Dominion; nay, rather, it was the price offered to British Columbia as an inducement to join the sisterhood of federated provinces. The surveys were commenced in 1871, and work was begun and languidly prosecuted for years, chiefly in the prairie districts, until the present company was organised, in 1880, when construction was pressed with such energy that the track was completed from end to end in 1884. The company now owns and operates a continuous line from sea to sea, and thus divides with the Southern Pacific the advantage of operating a perfectly independent road from tide-water on the Atlantic to tide-water on the Pacific.

The line from Montreal to Vancouver divides itself naturally into three main sections, distinct in their geographical features.

a. The First Section.—This section follows, for part of the way, the old *voyageur* route from Montreal to Georgian Bay up the Ottawa and the Mattawan and along Lake Nipissing. Thence it cuts across country to Lake Huron, and skirts the north shore of that lake and of Lake Superior, running between Lakes Superior and Nipigon to Port Arthur and Fort William, on Thunder Bay, Lake Superior.

This whole region, from the Ottawa to Fort William, a tract of 670 miles in length, with a width of 300 miles between the lakes and Hudson Bay, covering, therefore, an area of 200,000 square miles, is, to all intents and purposes, unexplored. The cold is not more excessive than in the province of Quebec, and the snow-fall is less, but most of the land is unfit for settlement, and there seem to be no such pine forests (unless, perhaps, in the valley of the Spanish River) as give immediate available value to the valleys of the St. Maurice, the Ottawa, and its eastern tributaries. But it is intersected at distances of about twenty-five miles by large and rapid rivers, along whose valleys, as well as among the labyrinth of lakes which occupy the Height of Land to the north of the Rocky River of Lake Superior, there are extensive areas of land peculiarly fertile in grasses and roots. The famous Sudbury copper and nickel mines give a forecast of the minerals which will be discovered in the Azoic and Palæozoic rocks that underlie the whole of this vast region, which the Canadian Pacific has opened up on the eastern slope of the continent,—a region larger than the whole of New England, New York, Pennsylvania, Virginia, and Ohio.

The real motive, however, for building this section was the military and

SUMMER AND WINTER TRACKS ON THE CANADIAN PACIFIC RAILWAY

political necessity of railroad communication between the members of the Confederation within Canadian territory. As it is, the Canadian Pacific has built an alternative road via the Sault Ste. Marie, to connect with roads south of Lake Superior.

The mention of Lake Nipigon recalls the doings of one of the paladins of northwestern exploration, whose exploits have been strangely overlooked in our day. In 1731 Varenne de la Verandraye was commandant of the French fort of Lake Nipigon, and heard the stories of Lake Winnipeg and the country beyond which the Jesuit Fathers, who ministered at the Mission of the Holy Spirit, on Lake Superior, had recorded in their "Relations" half a century before. They fired him with the true enthusiasm of adventure; and, aided by a Canadian commercial house and permission from the French Crown, he spent the remainder of his life in exploring the routes of the Northern and Canadian Pacific railroads, more than half a century before Lewis and Clark's day. He ascended the Missouri to the Rocky Mountains, but did not cross them. Subsequently he explored the Assiniboine and Saskatchewan, dying almost on the summit of the Rockies in 1749, trying to reach the great Bitter Sea, which his Indian guides told him was so near.

This northern zone of the continent, though so cold, or rather because so cold, was better known than any toward

the south till we reach the Spanish provinces of Mexico and California. The French had tracked it for furs, and they had established in it missions and trading stations. Contemporaneously the Hudson Bay Company was trafficking with the Indians for their furs at posts along the margin of Hudson Bay.

The two Canadian companies of fur traders consolidated in 1805 into the Northwest Company, which had its headquarters at Fort William, and drew its furs from every stream of the great prairies and mountains to the very shores of the Pacific; with it the Hudson Bay Company soon competed for the peltries of the interior. It was to check or share their trade that Astor sent out his expedition to found Astoria, on the Columbia River. I have already mentioned Mackenzie's first recorded trip from sea to sea by way of the Peace River. Frazier, another fur-trader, reached the sea by the river which bears his name. But not only had this section of the continent been explored with sledge and canoe by the fur-traders: in its heart, at the confluence of the Red River with the Assiniboine, Lord Selkirk, recognising the marvellous fertility of the Manitoba prairies, had taken steps, in 1811, to found his unhappy colony.

His views on many social subjects were as much in advance of his generation as were those of Paterson when he founded his ill-fated Darien colony. The times were not ripe. Many concurrent circumstances must combine to insure success in great social movements. The movements create the circumstances, and the circumstances again stimulate and propel the movements. But when they originate in some individual effort, no matter how philanthropically noble or theoretically correct, they generally end in disaster.

b. The Second Section.—From Fort William,* on Thunder Bay, what was for a time the second section of the road follows the valley of the Kaministiquia and Mattawan for fifty miles till it reaches the low water-shed between Lake Superior and Hudson Bay, not far from where this Laurentian ridge, throwing off a spur, deflects its waters, some to the Great Lakes, some to the Arctic Sea, and some to the Gulf of Mexico. From this point, for 400 miles, till the Red River is approached, the road skirts a chain of these numberless lakes, which here contend with the amphibious land for complete dominion. It is strange in this far northern clime to find vegetation growing so rank as to build up land in the water. Yet the *muskeg*, or *sink-hole*, of these vast swamps is the outgrowth of such floating islands as surprised the Spaniards in the Lake of Tezcuco, and so seriously obstruct the navigation of the upper Nile. Here they seem to be solid land till the railway builder commences to weight them down with his embankment, when their hollowness becomes apparent. At Barclay the road crossed a *muskeg*, beneath which, it was estimated, from the amount of filling required, that there must have been a cavity 200 feet deep. It is unnecessary to point out through what a different climate and country the road passes from that traversed by its southern rivals. The lake region, it is true, commences within the confines of the Northern Pacific. There the lake offers an agreeable diversion from the land; here the land, unfortunately, has to be looked for as a diversion from the water. Further south, the land languishes for want of moisture; here it is drowned by a surfeit of water.

c. The Third Section.—Happily, in the third section, the prairie division, the balance between land and water, rainfall and drought, is better maintained than in any prairie region of the whole West; and were it not for the great cold of the winter months, and the early August frosts, the fertile belt of the provinces of Manitoba, Assiniboine, and Alberta, for 800 miles westward from Winnipeg to Calgary, would claim undisputed pre-eminence in value as farming and grazing land over the regions

*An opposition road is being built from Fort William to Winnipeg; it will run much nearer the United States line, and traverse the northern extension of the Mesabi range, in which indications of great iron wealth have been discovered, and give access to the Shebandowan gold-fields.

tributary to any of the southern roads. The remarkable leniency of the climate along the base of the Northern Rockies, even as far north as Lake Athabasca, has always been a matter of surprise, and is more or less a meteorological puzzle. It is, however, a fruitful fact to the Canadian Pacific.

From the rim of Lake Superior to the Red River, near its discharge into Lake Winnipeg, the road follows the water-highway with a regular down grade. From Winnipeg west it ascends the valleys of the Assiniboine and Saskatchewan. The country traversed rises by three steppes,—that of the Red River, with an elevation of 800 feet, through that of the Qu' Appelle district, whose elevation is 1600 feet, to the Calgary plateau, with an average altitude of 3000 feet. At Morleyville the foot-hills are reached, and at Radnor, 904 miles from Winnipeg, the main range is entered through the Bow River pass. The ascent thence is easy to the summit, where, at 960 miles from Winnipeg, from twin lakes nestling in a valley four miles wide, two streams flow, one to the Atlantic, another to the Pacific. The mountains rise formidably on each side of the valley, but the divide is passed by grades which, except for the upper five miles of the Bow river, where they attain 116 feet to the mile, nowhere exceed 40 feet.

Thus the Rocky Mountains are crossed at an elevation of 5300 feet, through a grassy vale, with glacier-clad mountains towering from 5000 to 6000 feet on either side, displaying all the sublimity in height and ruggedness of the Colorado Mountains, in contrast with forest and verdure more suggestive of Alpine scenery than anything else upon the continent. Down the westbound stream the track follows the Kicking-Horse River for forty-seven miles, to the Columbia, here flowing in a broad stream to the northwest. Down the Columbia River it descends, though here this glorious stream, which begins with a width of a mile, is rather a long, sinuous lake than a river. The Selkirk range lies coastward, and over it the road now passes by the aid of the Beaver River valley at an elevation of 4300 feet, to again meet and cross the Columbia, now flowing southwest. The grades, in descending from the main range into the valley where the Columbia is first crossed, in ascending the Selkirk range, and in again descending by the Ille-Cille-Wact into the Columbia valley, to cross it by the second bridge, are, for short distances, 116 feet to the mile. Another range, the Gold range, has still to be crossed, by the Eagle pass, the three ranges following like waves of decreasing volume. Westward of the Gold range the road enters the valley of the South Thompson, and skirts the banks of the Shuswap Lake (with one leap over an obstructing promontory) and the South Thompson River to Kamloops, where the North and South Thompson unite and discharge their streams into Kamloops Lake.

From Kamloops the road follows the lake, and the Thompson, and finally the Frazer River, through the gorge which it has cut through the Cascade range. At the mouth of the gorge is Yale, and, fifteen miles below, is Hope. Below Yale the waters become tamer, and at Hope they are navigable for river-boats to Westminster, a port of capacity sufficient for the largest ships. Twenty-six miles from Port Hammond, where the railroad leaves the Frazer River, is Vancouver, the terminus of the road.

To identify the geographical features of the section is more or less guesswork. The first and highest range crossed is undoubtedly the Rockies. The last range, not crossed by the railway, but penetrated by the gorge of the Frazer, is generally identified with the southern Coast range. It more correctly corresponds, I think, to the prolongation of the Sierra Nevada, the Gulf of Georgia occupying the coast-valley, and the Coast range surviving in the island of Vancouver and the Queen Charlotte group. The intermediate ranges, the Selkirk and the Gold, are probably homologous with the Wasatch and Humboldt; but the crushing together of the whole mountain system has obliterated the great valleys; and the change in climate, resulting in the creation of

numerous large and impetuous rivers, has introduced eroding, modifying influences, not so appreciably felt in the configuration of the southern mountain and valley system. From the base of the Rockies at Cheyenne, on the Union Pacific, to the foot of the Sierra Nevada at Colfax is 885 miles. On the Northern Pacific route, about 500 miles north of the Central Pacific, between corresponding points, the mountain system is 590 miles wide; whereas from the base of the Rockies here to what we may assume to be the base of the Sierra chain is only 330 miles.

The scenery of the mountains in this parallel is modified not only by these geographical variations, but by the heavy clothing of forest trees. Unhappily, these features will rapidly disappear, for it is no more in the nature of a Canadian than of a Californian to plant for posterity a sapling to replace the tree he cuts down.

STATISTICS AND CONCLUSIONS

This rapid sketch may be appropriately supplemented by tables of distances, and other statistics.

	Miles.
Union and Central Pacific.	
San Francisco to Omaha	1867
Omaha to New York	1412
	3279
Southern Pacific.	
San Francisco to New Orleans	2476
New Orleans to New York, by rail	1373
	3849
San Francisco to Galveston	2133
San Pedro (port of Los Angeles) to New Orleans	2021
San Pedro to Galveston	1678
Atchison, Topeka and Santa Fé.	
San Diego to Chicago	2347
Chicago to New York	912
	3259
San Diego to Galveston	2437
Northern Pacific.	
Seattle to St. Paul	1923
St. Paul to New York	1320
	3243
Seattle to Duluth	1939
Great Northern.	
Everett to St. Paul	1790
St. Paul to New York	1320
	3110
Everett to West Superior	1849
Canadian Pacific.	
Vancouver to Montreal	2906
Montreal to St John, N. B.	481
	3387
Vancouver to Port Arthur	1913

The Southern Pacific port of San Pedro, from which to Galveston is by far the shortest transcontinental railroad distance, is not available for ships of large tonnage, and San Diego, the Pacific terminus of the Santa Fé's own line, by no means possesses the capacity or the trade of San Francisco. The Santa Fé is building across the great plains of Central New Mexico and Texas to connect Albuquerque with its gulf line, which connection will shorten the distance from sea to sea, and escape the heavy grades of the Glorieta and Raton ranges; but the unfavourable location, as shown by the profile map, of the Santa Fé Pacific, places the road at a disadvantage, as compared with the Southern Pacific. The comparison of distances from sea to sea is in favour of the Southern Pacific, but the comparison of profiles somewhat favours the northern roads. The advantages which fit them to be economical freight haulers lie, therefore, between the northern roads and the most southerly of the six competitors. Climate is, however, an important factor when we are judging of the commercial value of each route. Cold and the snowfall are influenced by altitude even more than by latitude. The Canadian and the Central in this respect stand almost on a par.

The road most favourably situated as regards climate is the Southern; but the semi-tropical rains of Southern California and Texas are, at times, as obstructive to traffic as the snows of the north. No road, therefore, can claim such geographical superiority over its rivals as to give it supreme advantage, and, therefore, relieve it from the necessity of maintaining a conciliatory attitude towards its competitors and its customers.

The total mileage, owned and operated by the great roads we have described, is as follows:—

TOTAL MILEAGE OF TRANSCONTINENTAL RAILROADS.

		Miles.
Union Pacific,	2985 miles	4272
Kansas Pacific,	746 "	
Oregon Short Line,	541 "	
Southern Pacific Co		5414
Atchison, Topeka and Santa Fé, including Gulf, Colorado and Santa Fé, Southern California, and Santa Fé Pacific		6946
Northern Pacific		4527
Great Northern		4698
Canadian Pacific		6547
Oregon R. R. and Navigation Co.		1059
Denver and Rio Grande,	1648 miles	2533
Rio Grande Western,	550 "	
Colorado Midland,	335 "	
Total		35,996

FOUR TUNNELS NEAR SPUZZUM, B. C , ON THE CANADIAN PACIFIC RAILWAY

The Denver and Rio Grande and its colleague roads, which have no outlet on the Pacific, have really no more right to be classed as transcontinental than the Chicago and Northwestern and other Western roads which are creeping across the Rockies; but the influence of this famous narrow gauge on the economical progress of Colorado entitles it to a position which none of the newer competitors for the traffic of the mountains can claim.

The amount of railroad capital represented by the transcontinental railroads under consideration reaches the stupendous figure of more than $1,700,000,000. Large as it is, this figure is calculable; but the influence of the roads on the political, social, and economical history of the whole nation has been incalculably great.

The influence of the railroads on mining has not been more important than the reciprocal influence which the mining industry has exerted on the railroads. The first interests to receive a stimulus were the lead mines of Utah and Nevada, on the completion of the Union and Central Pacific railroads. Shipments of the richer argentiferous lead ores preceded smelting up to the years 1872 and 1873, even as the shipments of the richer copper ores of Montana were made in advance of the advent of the Utah and Northern Railroad into Butte. But not until the metallurgist came to the assistance of the miner, and the railroads supplied moderately cheap fuel, did the West become the controlling factor in the production of copper and silver which she is to-day in the market of the world.

The beginnings of gold and silver mining in the Eastern range of Colorado antedate the arrival of the railroad; but only when the Union Pacific system reached Denver could the sulphurets of Gilpin county be smelted into mattes, or the refractory ores of Clear Creek county be advantageously treated.

The discovery of Leadville and the active development of both mining and metallurgy in that direction were the most potent agents in stimulating railroad building, the exploitation of coal mines, and the manufacture of coke in Colorado. There alone in the West, moreover, coexist iron ore, coke, and a market large enough to warrant the manufacture of iron and steel,—an industry which everywhere has important reflex influence on railroad building and railroad prosperity. The raw material of iron manufacture is by no means confined to Colorado. The iron ore deposits of Silver City, New Mexico, are both extensive and rich, but conditions are not yet favourable for the active economical development of these and other similar iron ore bodies. There is coal in Central and Southern New Mexico, but the beds are so fractured and faulted as to have made mining heretofore less profitable than on the regular coal-beds of the Raton range, both in Colorado and New Mexico. These afford the most available supply of fuel for both the locomotives and the furnaces of the Southwest. The statistics of 1898 give the product of bituminous coal in Colorado as 4,125,206 tons; of coke in Colorado as 445,925 tons; and of coal in New Mexico as 863,583 tons. The Wyoming coal mines are credited with 3,181,905 tons. Montana's coal production has reached 1,450,471 tons, and the coal is of a quality which relieves the smelters from drawing any longer a notable supply from the Canadian northwest. Washington, even, contributes over 1,988,288 tons to the ever-growing demand. Thus these Western coal areas, so recently opened, contribute nearly 12,000,000 tons, or about 7 per cent., of the country's total production of bituminous coal.

Copper has been, after coal, the most essential auxiliary of all the mining products to the Western railroads. Its bulk, and the large proportion of fuel consumed in the reduction of its ores, have made it one of the most valuable items of Western freight. At the same time, the copper industry owes its origin and growth entirely to transportation facilities.

Though the Longfellow mine, in Arizona, smelted small quantities of ore with vegetable fuel, and shipped small

quantities of copper for 700 miles to the nearest railroad station on teams which had brought merchandise into the valley of the Rio Grande, only the exceptionally high price of copper in the '70's permitted this. It was not until the Southern Pacific, from the West, and the Atchison, Topeka and Santa Fé, from the North, made a junction at Deming, that the Bisbee, Clifton and Globe districts became notable producers. So also, though small quantities of rich argentiferous ores were shipped from Butte to Corinne, on the Central Pacific, before the Utah and Northern was built, Butte did not rise into prominence as a copper producer until that road had reached Silver Bow county, in Montana. Now, the copper industry of Montana must supply the railroads directly with about one million tons of long-haul freight in and out, and about two million tons of short-haul freight; and the Arizona copper industry gives them about half a million tons of long-haul freight. If the trade of the Pacific were always to be from west to east, there would be a superfluity of transportation facilities; but the current is sure to turn, and ere long there will be a heavy freight traffic to Pacific ports. It is not reasonable, to take a single instance, that Western copper should continue to be shipped from the Middle West to the East and Europe, there to be manufactured into specialised shapes and sold to the Orient as India sheets, or in any other form. Coal, skill, transportation and shipping ports are ready to hand, and the Western miner and metallurgist will, ere long, become a manufacturer, under the influence of these beneficent harmonisers of sectional interests,—coal and railroads.

As the United States is a country of great distances, this is especially true. If coal were not widely disseminated, and fuel for locomotives had to be hauled a thousand miles or more, American freight charges could not be, as they are to-day, the lowest in the world. And if coal were confined to a few and distant regions, manufacturing could never have become, as it has done, a common occupation of every section of the land; but the West would still be a grain producer, the South a cotton grower, and the metal and manufacturing interests would be confined to the Middle and North Atlantic States. As it is, thanks to the abundance of coal in Illinois, Chicago and other towns in that State are as conspicuous for their steel and other manufactures as Pennsylvania itself. The "New South," with its great coal resources in the Virginias, Tennessee, and Alabama, is to-day fixing for the older iron States the price of pig-iron, and is converting into textile fabrics her cotton in her own factories. This interfusion of manufacturing and farming is effectually correcting the old sub-division of the country into communities of opposing interests, and, therefore, of conflicting prejudices. Even what was till recently the "Far West" is entering the community of manufacturing States, owing to the possession of coal. Not only do coal and prosperity go hand in hand, but coal and politics are close allies.

It was the discovery of gold in California, and the rush thither to reap a golden harvest without sowing any seed, which stimulated the peopling of the west coast; and it was the Mormon exodus from Illinois, the very same year, and the conversion, by these religious fanatics, of a tract of country in the very heart of the great desert into an oasis of beauty and fertility, which proved that the mountains would yield other products than the precious metals. Miners and Mormons were, therefore, the elementary material out of which Western life was originally composed.

While other elements have since been introduced, mining and ranching are still its staple industries, but both are pushed with an energy and intelligence beyond comparison. Western fruit, Western wheat, Western cattle are feeding the world. For the rate of discovery and recovery of the precious metals we have to look back to the years following the Spanish conquest of the continent to find a parallel. The Pacific railroads have, to all intents and purposes, doubled the area of the United States and Canada, and they have done it in

the short period of thirty years. A region 1000 miles wide by 2000 miles long, rich in minerals, and utterly virgin ground, was scoured. It is practically bare of soil and unconcealed by forest, and, therefore, exploration has been easy and discovery rapid; but hardly more rapid than the avidity with which the discoveries, once made, have been utilised.

The statistics of the precious metals mined since 1849 afford proof of this. Between that date and 1898 the Rocky Mountains yielded about $4,500,000,000 in gold and silver. The Comstock lode alone produced, from 1860 to 1880, $306,000,000 in gold and silver. It is worthy of note that on the construction and equipment of the whole 40,000 odd miles of railroad in the Rocky Mountain system there has been spent more than one-third the total production of the precious metals.

Despite the relatively small value of copper, its mining and reduction have been pursued with the same haste, a haste which, in this case, as in that of the precious metals, has necessarily involved a heavy waste. The great copper mines and smelting plants designed on such a stupendous scale have been the controlling factors in the world's copper market for the last twenty years. The quantity of copper they have turned out has been approximately 3,500,000,000 pounds.

But the men themselves have had almost as powerful an influence on the world's history as the production of their hands and brains has had on the world's markets. The isolated outdoor life passed by the herdsmen, prospectors, miners, and ranchers of the Rocky Mountains and the Pacific slope, far from the restraints of society, has created a race which acts under very different impulses from those which kept the New England and Virginia colonists content with their narrow home between the Atlantic and the Alleghenies. And the self-assertive, though generous, spirit of the pioneer, who is untrammelled by precedent or prejudice, has communicated itself to the mercantile and technical classes of the West, and thus has helped, not a little, in fostering its extraordinary rapid growth. These men of the American West are the real *coureurs de bois* of our day, and Acts of Congress would be as powerless to restrain them as were the *édits et ordonnances* of the French governors to check the roving habits of their predecessors. Wherever there is a new country to explore, if it contains minerals, these are the men to explore it. Let there be a great gold discovery in arctic or tropic regions, in the Klondike, or in Central Africa or New Guinea, and a contingent will start from the Rockies by the earliest train to catch the first steamer, with no baggage but its blankets,—and the expedition will reach its goal, wherever that may be.

THE INDUSTRIAL SUPREMACY OF GREAT BRITAIN

TRADES UNION AND OTHER ADVERSE INFLUENCES

By James B. Alliott, M. Inst. C. E., M. Inst. M. E.

IN what is given in the following pages the writer has not attempted to deal at all fully with the various questions affecting the prosperity of engineering enterprises in Great Britain. His remarks are intended merely as suggestions of various directions in which influences may be found, either now at work, or which have been at work, and which have acted injuriously upon British industries.

Let it first be stated that the writer does not take a pessimistic view of Great Britain's position. Although it is perfectly true that, at the present time, there is a contraction of British trade and a falling-off of orders, the same conditions prevail to a large extent, if not even to a greater extent, in Germany, and possibly in other countries also. The wars in South Africa and in China are responsible for very large stoppages of orders, and are, doubtless, to a considerable extent responsible for present depression. There are, however, many other causes which have had a distinct influence in driving work away from Great Britain and directing it to other countries. Take, for instance, the question of British legislation.

Let us consider a few instances only of legislation which has acted adversely to the manufacturers of Great Britain. There is, for example, the Merchandise Marks Act under which all goods imported from abroad must be labeled with the name of the country from which they come. One effect of this has been to force British merchants to advertise their foreign competitors. What would be thought of a confectioner whose windows and shop were full of articles labeled thus:—" These buns, or these cakes, or these tarts were made by Berlin, Hamburg & Co., across the way." Of course, the man's customers would go across the way to Berlin, Hamburg & Co., where they would expect to get the same things fresher; and if the confectioner were to state that he did this because he thought the goods thus labeled were of inferior quality, but that he sold them because his customers would have them, the general verdict would still be that the man was a fool, and was inevitably driving his customers elsewhere. This, in fact, has been the effect upon British trade, and not only articles which have been thus labeled have been purchased in Germany or in other countries, but direct relations having once been established, many other articles have been bought there also. The extent to which British industry, as well as British trade, has thus been damaged is exceedingly difficult to estimate, but the mischief has certainly been very great.

Next, take the Act passed many years ago preventing any road locomotive from running at more than four miles an hour, and further requiring that a signalman should precede it. At the time that Act was passed, road locomotives were actually being built which were fairly successful, and which were capable of carrying passengers with moderate comfort and at a fair speed. That Act, however, killed the business, and though Great Britain was the first to enter upon the industry of making road locomotives, it was absolutely prevented by legislation from again taking up this business until other countries had proved its practicability on a considerable scale and had obtained a degree of experience and a

lead that easily placed them far ahead of Great Britain in the struggle which is now going on for this class of work. It is true that changes in legislation have enabled Great Britain to start the manufacture, but much leeway has to be made up before the lost supremacy in this line of business can be regained, and a stern chase is proverbially a long chase. Even now legislation bears harder upon the manufacturer and the user of automobiles in Great Britain than it does in many other countries.

Let us next consider the legislation which has affected electric lighting and electric tram work. This legislation had been adopted in the supposed interests of the public in order to ensure their safety, and in order, further, to make it impossible for private individuals to obtain such profits, and security for their property, from enterprise of this kind as were obtained formerly by gas companies and water companies. These objects, so far as they tended to protect the public, were, no doubt, good; but their effect was for a long time to make British investors unwilling to risk their money to any considerable extent in enterprises of this kind. All the risks of the undertakings were still left with them, but as soon as prosperity and good dividends seemed assured, the investors were liable to have their property taken away from them. The result has been that electrical enterprise in Great Britain has languished, while in countries where it was comparatively free from restrictions it has prospered. These reasons have probably had as much to do with limiting the amount of electrical work performed in Great Britain as any questions of manufacture.

The limiting of electrical enterprises generally has had an adverse influence upon manufacture because it has turned the attention of many from electricity to other things, and thus has prevented the amount of thought, skill, and money being devoted to developing the manufacture of electrical appliances which their importance would otherwise certainly have warranted. Here, again, because of the comparative fewness of these enterprises in Great Britain, and because of the comparatively small degree of attention which, so far, has been given to them, much of the necessary experience has to be sought abroad, and much of the machinery also has been bought abroad, not because it could be made better there, but because British manufacturers could not point to successful plants on the same scale as could be shown elsewhere.

Fortunately, these influences are now less potent than they were in the past, but still legislation to-day weighs far more heavily upon the development of electrical enterprise in Great Britain than it does in other countries.

The Workmen's Compensation Act also has its share in affecting the cost of work, and that not so much because of the amounts which are actually paid in compensation, but because its action, taken in conjunction with the trades unionists' insistence upon a minimum wage, has made it more difficult for the skilled workman over fifty years of age to obtain employment. As a matter of fact, a close examination into accidents and the classes of men most subject to them, which has arisen out of the application of this Act, has shown very conclusively that, contrary to the expectation of many people, accidents happen much more frequently to old and experienced men over fifty years of age than to the young and presumably more careless. When, therefore, a man, through failing sight and decreasing energy, is unable to do as much, or as good, work, as formerly (while at the same time the trades union says that he must receive the full minimum wage or he must not work at all), the tendency is for the man to be put on one side, and to fall altogether out of the ranks of skilled workers, thus limiting their number, and causing an artificial restriction upon the labour market.

As this article is to deal only with engineering industry, the writer will merely allude to various Acts affecting shipping, with respect to which others are far more competent to speak. The writer thinks it is fairly clear that however beneficial these Acts may be in some ways, they nevertheless impose

expenses upon British shipowners to which owners in other countries are not subject. They thus affect the demand for shipping and for marine work generally.

While Great Britain prides herself, as a nation, upon her strict adherence to free trade principles, the government has not considered that the legislative fetters which have been imposed upon some, at least, of the British industries have been in contravention of these principles. While thus handicapped the British manufacturer is told to go out and hold his own in the markets of the world, and to fight with, and beat, protected industries of the foreigner; and he is told to be thankful that he lives in a country where trade is free. In at least one case, that of sugar, while the government has refused to protect industries carried on in Great Britain and in British colonies, it has permitted the foreigner to step within British customs boundaries and there gives whatever protection he choses to similar products from foreign lands and foreign factories, and this has been, and is still, declared to be in accordance with the principles of free trade.

To come now to the relations between masters and men, and especially to the effect of trades union rules, let us say at once that there is no reason why trades unionism should not be of great benefit both to men and masters, and that whether it is a benefit or a mischief depends altogether upon the way in which it is conducted, and upon the aims and beliefs both of its adherents and of those who are at the head of its organisation. In the London *Daily Express* of recent date Mr. Barnes, secretary of the Amalgamated Society of Engineers, says that "one master speaks of the 'fatal economic mistake' of the trades union leaders in the matter of restricting output," and he goes on to say that "trades union leaders are not the fools" that that master "assumes them to be"; but he does not say that trades union leaders do not favour, and never have favoured, the restriction of output. The question is not at all whether trades union leaders are fools or not. Most of us believe them to be clever, able men, but the policy of the unions may be a mistaken policy, for all that. The question really is, Does the action of the unions, whether of their leaders or of their members, cause work to be more costly than it is elsewhere, even where wages are higher? And the answer to that question most assuredly is that in very many cases the action of trades unionists, imbued with ordinary trades unionist ideas, has produced this injurious effect.

So far as can be judged, both by their rules and by their actions, the object of many trades unions is, first, to keep all their members employed; second, to make, if possible, a "corner" in the particular kind of skill possessed by their members; and third, to use this "corner," or artificial scarcity, for the purpose of advancing wages, no matter whether the industry in which they are engaged suffers by such advance or whether it can bear it. They have no thought whatever for anyone outside their own organisations. This is shown by the strict limitations which they endeavour to impose upon the number of apprentices, and by their strenuous opposition to the advancement in the wages and position of labourers which results when labourers are put in charge of machines which they are quite competent to work.

Their first object, that of keeping their members employed, is, of course, a most desirable one, and the same may be said for the desire to advance the wages of their members, providing this can be done without injury to trade. The second object, that of creating a "corner" in labour, is just as mischievous to the public as the creation of a "corner" in corn, or in cotton, or in shares.

Let us consider for a moment the position of a foreman who is a member of the Amalgamated Society of Engineers. One object of this society is to keep all its members employed, and, in the particular branch of which this foreman is a member, let us assume that there are several men unemployed. The officials come to the foreman and

say, "We have so many members unemployed. Can't you find work for them?" If he answers, "Well, I have as many men as I want," the probable reply is, "Put another man on, and let them work a little slower."

The man is employed, but what about the effect on the cost of the articles made, which have to compete with articles manufactured in Germany, or in the United States? Then, again, a society foreman may not employ even the best non-union man, provided there is a society man wanting work, even though he may be a very inferior man, because passing over a society man in order to employ a non-unionist would make the foreman liable not only to very unpleasant remark from the union officials before whom he might be called, but also to fine or other, possibly more severe, disciplinary measures.

Mr. Barnes may say that such conduct is contrary to the wishes of the responsible heads of the society, though very possibly he may uphold it. In any case, such action has taken place frequently in the past, and it will take place frequently in the future where union officials are more zealous for the temporary well-being of their branch, or of their society, than they are for the prosperity of the master by whom their members are employed.

In trades union shops there may be found a trades union official, not ticketed as such, or accredited to the employers as such, but nevertheless there upon their premises, whose duty it is to note the work the men do, and the time they take to do it. He also considers it a part of his duty to warn the men that a particular job has hitherto taken so many hours to do, and must not be done in less. Here, again, Mr. Barnes may declare that he knows nothing of such practices; but whether he knows of them or not, they have been, and are, most widely prevalent.

It is well known that the Amalgamated Society of Engineers has set its face resolutely against one man working more than one tool. Before the great British strike of three years ago it was practically impossible to get a man to work two lathes in any except the few shops in which working more than one tool was an established custom, of old date; and even in some of such shops endeavours were made to restrict the custom, or to abolish it altogether. Suppose a British turner to receive from 36s. to 40s. a week, and to work one tool only, and an American turner to receive, say, 60s. a week, and to work three tools, how can the British manufacturer expect to compete in cost of production with the American, even supposing the tools to be worked at the same speed? If, however, the British workman is left to himself, he will probably run his tool at a very low speed, while the American, especially if he is doing piece-work, will certainly run it as fast as he can.

In regard to piece-work, which is most bitterly opposed by the Amalgamated Society of Engineers, it is true that an unscrupulous employer may abuse the system; but it is, nevertheless, the fairest way of remunerating labour, and at the present day it is practically the only way which permits the employer at once to pay high wages and to make a profit.

One knows that eighty or one hundred years ago the most strenuous opposition was offered to the introduction of machinery in the textile trades, and to-day everybody knows that that opposition was not only futile, but foolish, and that the working classes, the weavers themselves included, have benefited, and not suffered, by the introduction of machinery. The only object of machinery is to enable one man to do the work of many, and to lessen the cost of the work he does. There is no place for the engineer in the world unless he effects this purpose; yet we have the anomaly of a society, representing a large part of the men earning their living by engineering, opposing, tooth and nail, almost every invention, and almost every arrangement between masters and men, which could result in a decrease in the cost of production; in fact, the men who have been called into being by the desire for cheapening production are, in their own trade, doing

all they can to prevent the attainment of this end. They are apparently afraid that the wants of the world are limited, and that if work is done more quickly and more cheaply there will not be enough to go round. There is no need for such fear. The cheaper the cost of production is, the more of the good things of this world will the poor be able to buy, and decrease in the cost of production is thus far more important for the poor than it is for the wealthy, since the poor are at present much more limited in their power to purchase on account of their poverty. Lowering the cost of commodities so that people can buy more of them will do far more to keep men prosperous and in work than any restriction of output.

British employers have been charged with apathy in regard to the introduction of special and labour-saving tools; and, as a matter of fact, until quite recently they have been far behind their competitors in America in the introduction and use of such tools. This backwardness, however, certainly ought not to be charged entirely upon employers. The greater part of the responsibility for it rested with the trades unions and the application of their ideas by their members.

There has been no inducement to introduce automatic machines in Great Britain, because, at any rate, in many cases in which the attempt has been made, the members of the Amalgamated Society of Engineers have refused to permit such machines to be worked by any save members of their own society, and they themselves have refused to work more than one machine, although the automatic devices may have been specially intended to enable one man to work several; and they have also, whether of set purpose or through unwillingness to be taught, failed to get out of such tools anything like the amount of work that they were capable of producing.

It was, of course, useless for an employer to put in a very costly tool and then find that he had just as much to pay as before in wages for work done. This has not only prevented British employers from making use of such tools, but it has also prevented British tool makers from devising them, and from manufacturing and endeavouring to push them, so that to-day the British engineer who wishes to be abreast of the times in regard to labour-saving machinery finds himself, to a large extent, forced to go to America to purchase tools, though he would willingly buy the same tools in Great Britain were he able to do so. This is a case in which the whole industry of the country has been kept backward, whilst others have marched forward, simply because of the policy followed out by trades unionists. Here, again, whether due to some degree of light having shone upon those directing the policy of the unions, or whether it has been due to the unions having less power to enforce their retrograde policy, much progress has been made since the great British engineering trades strike, and to-day some of the newest and most effective labour-saving tools are to be found in many British shops.

In the article in the *Daily Express* before referred to, Mr. Barnes is stated to have said that while the Amalgamated Society of Engineers insists upon a minimum rate of wages, there was nothing to prevent employers from paying at a higher rate than this. To the outsider this may appear to be a perfectly clear and plain statement, yet, as a matter of fact, there are two very distinct reasons which prevent employers from paying anything beyond the minimum, except in very rare cases. One of these is that the trades unions, having, to some extent, succeeded in producing a close and restricted market for labour, masters are obliged to employ slow and inefficient workmen, as well as more able ones, if they are to get their work done at all, and these slow and inefficient men must be paid the minimum wage, although the work done by them does not really warrant it. Seeing, then, that they are forced, by trades union rules, to overpay some of their workmen, employers can recoup themselves only by not paying anything beyond the minimum rate even

to more efficient men, for they sell in the markets of the world, and the wages fund is the only one out of which efficient and inefficient workmen alike can be remunerated.

The other reason is this, that if any considerable number of workmen in a district were paid in excess of the minimum wage, the average wage of that district would rise, and with it the minimum rate of the district would rise, too. It will be seen that this is very effectual in making masters unwilling to pay any of their workmen at a rate beyond the minimum; for, if they do, they at once raise the minimum rate and the remuneration of their most inefficient men. Mr. Barnes must be familiar with this fact, although he has omitted to state it.

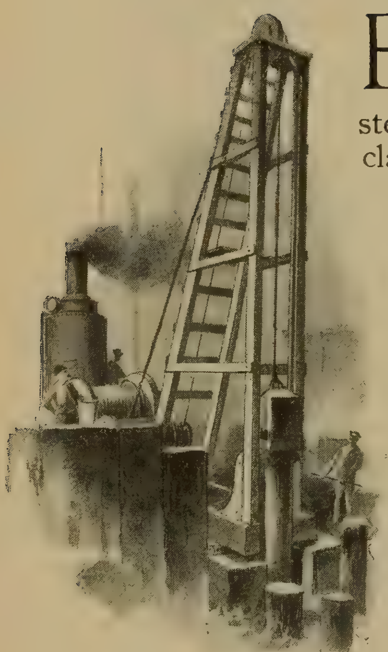
In the same article Mr. Barnes makes a reference to collective bargaining, and objects to the settlement of a piece-work price between a workman and his employer. It is obviously impossible, for the settlement of each piece-work price in each shop, to call in the whole body of employers and the whole body of workmen. There is no organisation which could possibly carry out such a work, and even if there were, it would probably take years to settle the price, and meantime the work would either have been done, or the demand for it might have utterly passed away. Mr. Barnes objects to the individual workman having to bargain with his employer, who may employ 50 or 100 such men, because, he says, the workman is put thus at a disadvantage; although, supposing the employer and the workman cannot fix upon a price, the workman can find hundreds of other engineering shops in which to work, none of which will be closed to him because he has not been able to arrange a price for a particular job with his former employer.

Mr. Barnes' idea is that the Amalgamated Society of Engineers, or the officials of its local branch, should make arrangements with the employer,—with the individual employer, be it remembered, for it is obviously impossible, as already pointed out, that the arrangement should be made with the whole body of employers. Mr. Barnes, therefore, thinks that there would be less of the individual bargaining if a society representing 90,000 men were to bargain with the employer who finds work for 90 than there would be if the individual man himself made a bargain with his employer; and yet the man and his employer are the two people on whose testimony the whole thing must eventually turn.

On the other hand, if the employer were unable to make a bargain with the society in regard to the particular job which was required to be done, the society could, and would, prevent any one of its 90,000 members from doing the work, and, where it had the power, it would also prevent non-society men from doing it, so that the individual employer would be absolutely at the mercy of the society. No doubt the society organisers would consider this an ideal state of things, but it is quite evident that it would not assist in making the business of Great Britain prosperous, or in enabling British products to find their way into foreign countries.

HOISTING ENGINES

By Joseph Horner



EXCEPTING, perhaps, the common portable steam crane, there is no class of hoisting machinery that possesses wider utilities than that known by the generic and very comprehensive term of hoisting engine, or steam hoist. These machines are ubiquitous for general service, but there are also special duties to which they are eminently adaptable. They are sometimes used for doing work for which hoisting machines of other kinds should be equally suitable, but only those cases will be considered in this article for which the hoisting engine alone is adapted, or for which it is usually better than any other type.

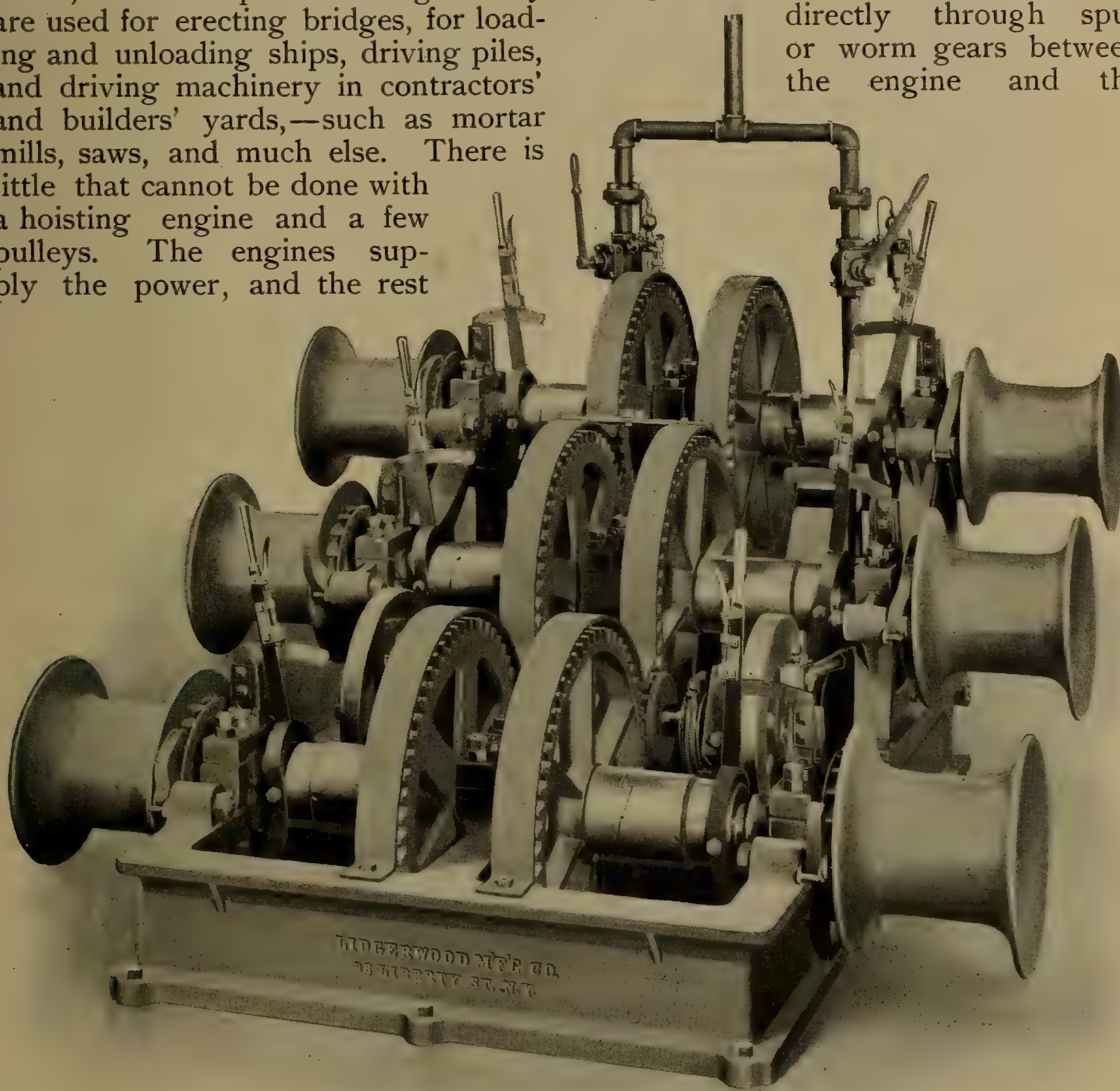
These hoists have not been so fully developed in Great Britain as they have been in America. There is no essential difference between the simplest types in each country. But the British hoist is seldom made capable of doing more than one thing at a time, while the most complete ones in the United States will perform several tasks simultaneously. The applications of the first are also more limited than those of the second. But the construction of hoisting engines is undertaken in America more as a specialty than it is in Great Britain, to the exclusion of nearly everything else. This difference is an important one, for firms are brought into constant and exclusive touch with builders and bridge erectors, contractors, miners, quarrymen, and others, and they are thus enabled to gain intimate knowledge of their needs, and to embody practical suggestions with regard to those minor details which contribute so greatly to the efficiency of the machines.

There are two principal features about these hoists that arrest the attention of the Englishman by reason of their novelty. One is their nearly universal application to the working of derrick cranes; the other is the multiplication of drums, and of winch heads, or spools,—using an American synonym. British derricks are entirely self-contained, being worked by hand, or by steam-engines, or electric motors attached to the mast; in the United States they are more often operated from a separate winch,—one drum dealing with the load, another with the lifting of the jib, or boom, or with the slewing of it. In Great Britain the employment of more than two drums is unusual, while one is by far the most common; in American practice as many as four are not infrequently fitted to one hoist, and occasionally six; in Great Britain two winch heads are the usual limit; in America four are very common, six are not unusual, and even eight are sometimes fitted. We note, therefore, at once in these American hoists developments resembling those which are embodied in the machine tools of the country, namely, increased capacity, brought about by duplication, with resulting economy in attendance, more rapid handling of materials, and more exact adaptations of types to special classes of work.

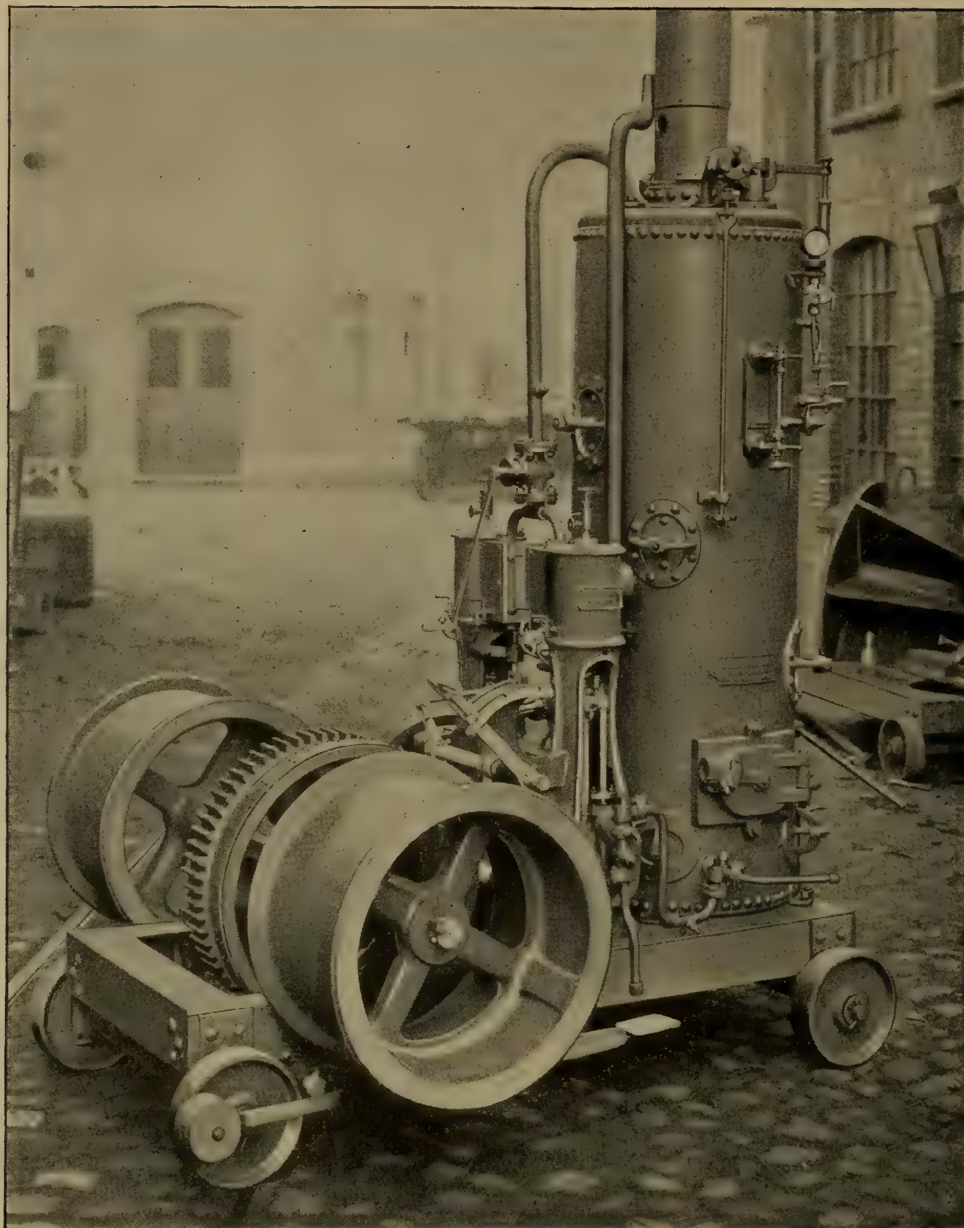
The elements of the simplest steam hoist are these:—Either a fixed foundation, or a carriage on wheels, with an engine, or pair of engines, driving a

hoisting drum, or drums, through gearing, with or without a brake. Yet in their numerous and varied modifications, and related types, these machines are capable of hauling loads on the level, or on inclines, or up vertical shafts, or to the tops of buildings. They are used for erecting bridges, for loading and unloading ships, driving piles, and driving machinery in contractors' and builders' yards,—such as mortar mills, saws, and much else. There is little that cannot be done with a hoisting engine and a few pulleys. The engines supply the power, and the rest is a matter of transmission and guidance. The hoist, variously modified, is driven directly by steam, gas, or oil engines, by compressed air, or electricity, or is belted, and it ranges in size from about 4 H. P. to 200 H. P.

For light loads and high speeds, as on coal wharves, engines are generally made of the direct hoisting type; that is, the disc crank is on the same shaft as the drum, and the latter, therefore, makes one revolution for each revolution of the engines. In this way speeds of 600 to 1000 feet per minute are attained. But for heavy loads the engines are geared, the drum being driven indirectly through spur or worm gears between the engine and the drum shafts. In the more common hoist or winch, as generally made in Great Britain, and in the simpler American types also, the drum is keyed fast on its shaft. This type is very well for some classes of work where lifting and lowering alone are being done, or where single loads only have to be handled. But for any service beyond



BRIDGE ERECTING ENGINE WITH SIX INDEPENDENT WINCHES, BUILT BY THE LIDGERWOOD MFG. COMPANY, NEW YORK AND LONDON



DOUBLE-DRUM SELF-CONTAINED PORTABLE ENGINE, BUILT BY MESSRS. MENCK & HAMBROCK, HAMBURG, GERMANY

this it is not so economical as others.

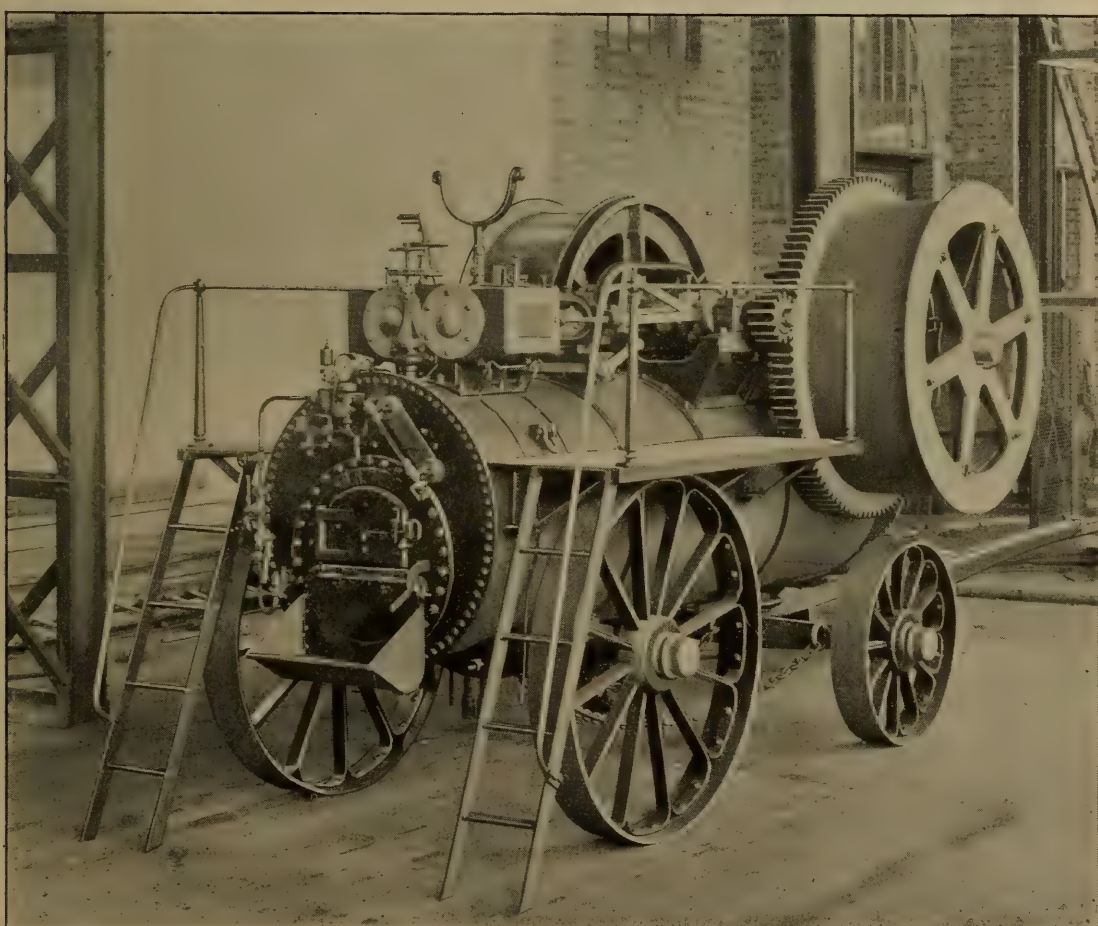
A more advanced type of engine is that in which two drums are used, and two winch heads, or warping cones, or spools,—the terms being synonymous,—are added on each drum shaft. The drums are then independent of each other, and can both be operated by one man, the levers being all brought into one place. One drum can be lifting, the other lowering, alternately. When the hoisting drum is thrown into gear the lowering one is thrown out. Two derricks can be worked by such an engine,—one being served from each drum. Or if there be only a single derrick, one drum can be used for handling the load and the other for moving the boom. In pile-driving also one drum can be used for bringing the pile into position and the other for actuating the monkey. By the addition of winch heads other work can be performed, and the drums can meanwhile be held by their pawls and ratchets with a load in suspension.

A particular application is that embodied in some hoists for swinging the boom of a derrick crane by power, simultaneously with the handling of the

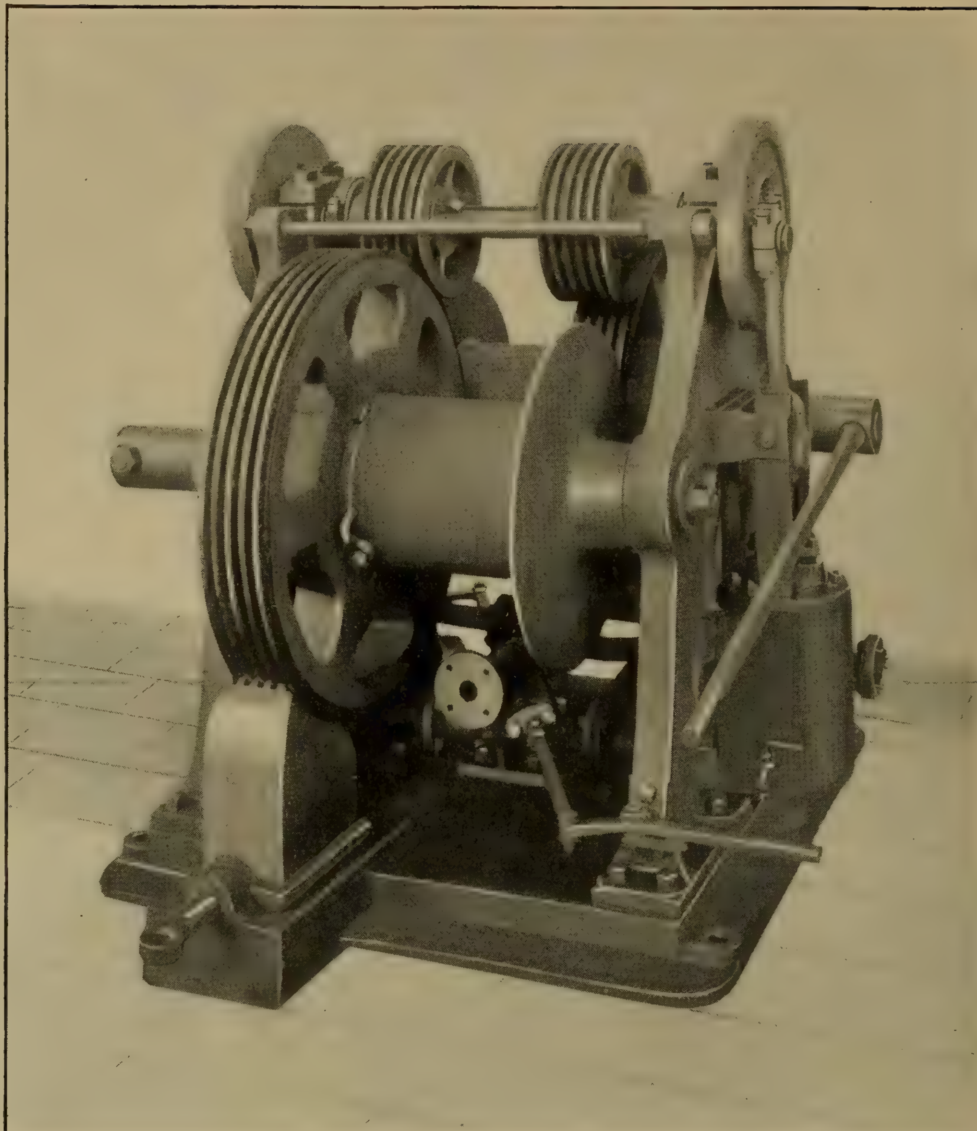
load. To effect this movement, two auxiliary drums are fitted on a shaft at the front end of the hoist, and geared down to about one-fourth the speed of the hoisting drums. Ropes are led from the turntable (the American synonym of the British curb ring) of the mast to the drums, and the throwing into gear of one or the other swings the crane in the required direction.

Many double-drum hoisting engines have grooved drums for mining work. They are modified in several ways, being arranged on one shaft in line, or in tandem fashion on two shafts. When arranged tandem, the advantage is that ropes can pass directly one over the other without the use of guide sheaves. Three-drum quarrying engines are made, in which each drum is independent of the others, for actuating three separate derricks. Ratchets, and pawls, and brakes are fitted so that loads can be held or lowered at discretion. A four-drum type of hoisting engine is also made. No complication is involved, for the levers from each are brought to the back in a row, including the foot levers for the brakes and the hand levers also for the friction drums. Notched yokes and quadrants prevent either from slipping while attention is being given to the others. Each pawl also has its cord brought to the front. Either one man or two men can operate this class of machine, which is suitable for derrick work. There are six-drum hoisting engines made, in which each drum is independent, with its own friction brake, and ratchet and pawl, the whole being operated by one man at the rear. The weigh shafts are connected by rigid levers to the drums. Such engines are of service in the rapid loading of vessels on wharves.

Though drums are usually fast on their shafts in the simpler hoists, they are, in many designs, left running loosely on them. They are most commonly thrown in and out of engagement by



ANOTHER FORM OF PORTABLE HOISTING ENGINE BUILT BY MESSRS. MENCK & HAMBROCK



A COAL WINCH WITH TWO INDEPENDENT BARRELS AND GROOVED FRICTION GEARING, BUILT BY MESSRS. CLARKE, CHAPMAN & CO., LTD., GATESHEAD-ON-TYNE, ENGLAND

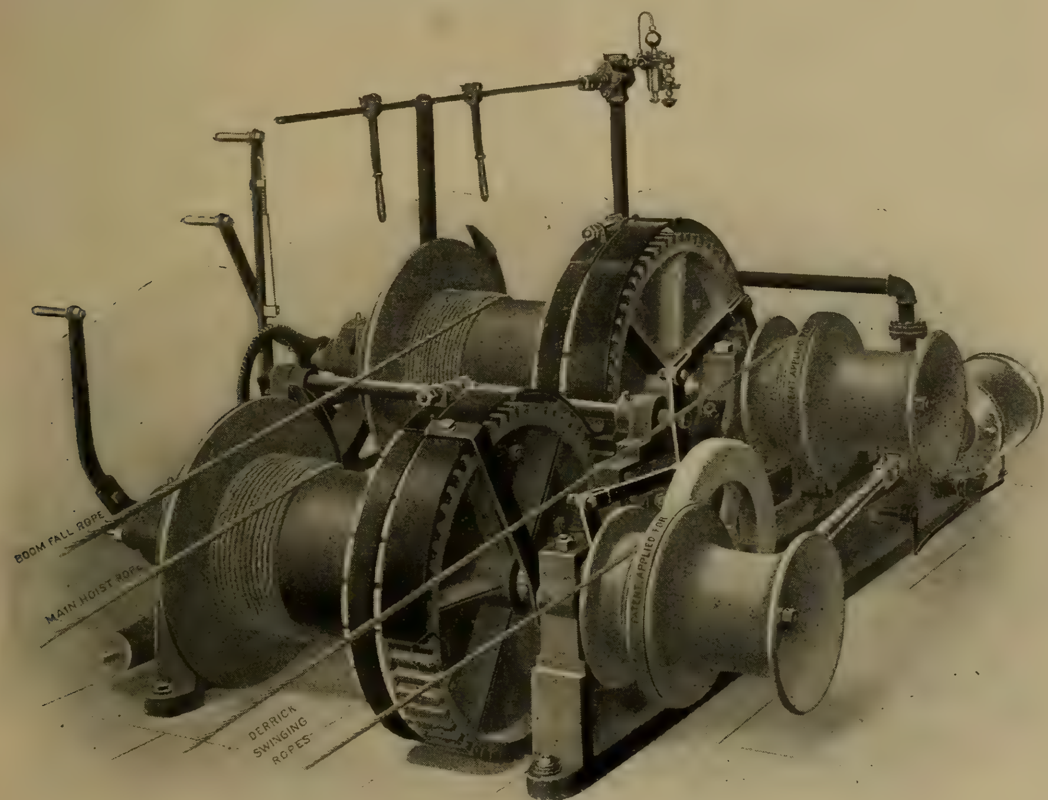
means of a clutch or other equivalent device, which can be safely effected only when the engines are stopped or slowed down. In the best and later American types, drums are thrown into and out of action while the engines are in motion by means of friction rings, a method which is now adopted very extensively, and forms a strong point of contrast with general British practice. This result is attained, with various differences in detail by different manufacturers, into the minute particulars of which it is not necessary to enter.

The loose friction type of drum is most commonly thrown into gear by a slight endlong movement on its shaft, effected by means of a lever, and it is released by the automatic pressure of a spiral spring interposed between the drum and the gear wheel with which it makes frictional contact. End thrust is taken by an ingenious thrust bearing and screw collar. The friction is effected by sections of hardwood bolted to the gear wheel, which are brought into frictional contact with the drum flanges by the lever. The blocks of hardwood are secured to a projecting brake ring on the wheel. The adjacent flange on the drum carries a ring beveled on the inner face to correspond with the bevel of the wood blocks. The wheel with its brake blocks is keyed on, the drum

running loosely on the same shaft. Leather frictions are also used.

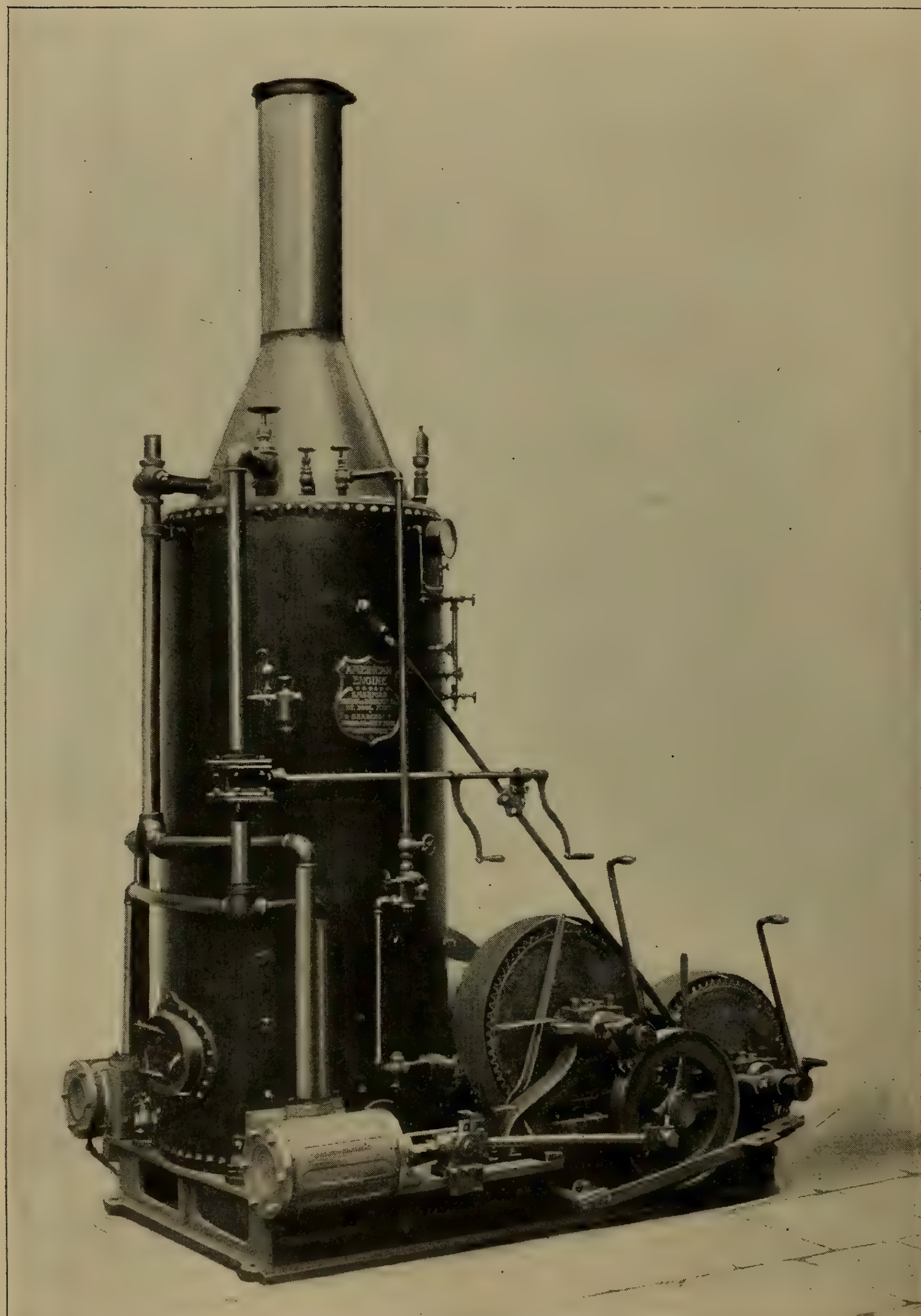
Although the friction drums are safe and suitable for all kinds of service, it is better to supplement them with band brakes in order to prevent the rapid wearing of the friction blocks. The reason is that in deep and prolonged descents the wear on these blocks is severe, and the heat generated is excessive, notwithstanding that the large diameter and wearing surfaces are conducive to a fairly long life. There is, under normal conditions, of course, no appreciable wear in hoisting. One of the American firms provides a central member with radial ribs outside the friction surfaces of two adjacent drums, to assist in carrying off the heat generated. The idea is to afford a large surface for its dissipation, and to keep the surrounding air in motion, so that the heat shall be removed the more rapidly. When winch heads or spools are used, it is necessary to have a band brake if the winch head is to be used at the same time that a load is hanging on the drum.

One special advantage of the application of the loose drum is seen in pile-driving. Instead of loosening the monkey from the rope, and having to re-attach the two before the monkey can be lifted again, the rope remains permanently fastened, and the monkey, in falling, simply overhauls the rope over the loose drum. After the blow has fallen the drum is thrown into gear again for the lifting of the monkey. In a British hoist, specially made for pile-driving, a novel arrangement has been embodied. The clutch and stop valve are coupled so that the engine is automatically stopped when the drum clutch is released.



A DOUBLE-DRUM ENGINE BUILT BY THE LIDGERWOOD MFG. COMPANY

Winch heads, warping cones, or spools, are more valuable for some kinds of service than for others. In bridge and builder's work where steel sections and timbers have to be handled constantly, the spools are great time savers, because each one may be simultaneously performing some separate task of hoisting. In hoists that contain both spools and drums the first can be occupied with their own proper duties while the



STANDARD HOISTING ENGINE BUILT BY THE AMERICAN HOIST & DERRICK COMPANY, ST. PAUL, MINNESOTA, U. S. A.

second are otherwise engaged. The spools in this case are not keyed on their shafts, as are those in the common hoist but run loosely when not in use, being thrown into action by means of claw clutches. Each spool has its own ratchet and pawl by which the load can be held suspended when the clutches are thrown out. The operating levers work in notched quadrants, thus preventing the clutches from becoming accidentally moved from their required position of in gear or out of gear, so that a spool, or spools, can be left safely with work in suspension for an indefinite period while other tasks are being done or adjustments being made.

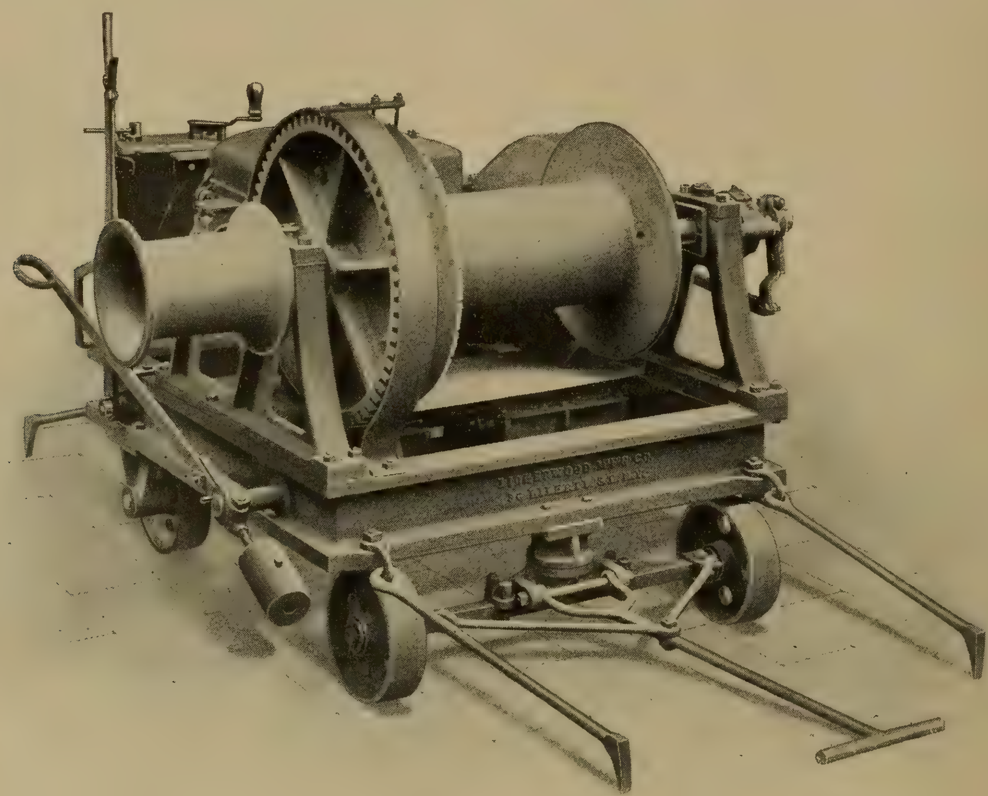
In the most advanced type of this kind, drums are altogether dispensed with, and six and sometimes eight winch heads are fitted in place of them, each being independent. These are eminently suitable for heavy bridge and tall building erection, on which large quantities of manilla rope with several falls have to be wound. For much work of this kind the lengths of rope used are so great that drums of immense size would be required to wind it all. Using spools, no rope is wound beyond the bight actually being coiled round them, the portion that is being payed out, or in, being laid in a coil in the rear. In this type the spools are keyed on their shafts, the driving gears of which lie within the bedplate on each side of a central shaft bearing. Each spool is driven by its own gear wheel that runs loose on the shaft, and is thrown into action by a sliding clutch. Each also has its shrouded ratchet and pawl for sustaining the load when the wheel clutch is thrown out. With this multiplication, several girders, bars, trusses, or timber beams can be hoisted into position and held fast by the several spools, the rope being anchored to any convenient spot while the work of bolting or riveting up is being done. We need not marvel that America excels Great Britain in the rapid construction of bridges and tall office buildings when the capacity of the single hoisting engine is multiplied half a dozen times or more in one machine.

A good, practical point to which attention is given in the best American hoists is the turning of the surfaces and balancing of the drums and spools. High speeds are thus easily attained without corresponding disadvantages, the smooth surfaces being conducive to long life of the ropes. Extension levers are fitted to hoisting engines when desirable, so that the man in charge can stand at some distance away from them, as at the mouth of a shaft or tunnel, operating them and taking charge of the skips and cages at the same time. In this arrangement the various levers and notched brackets are brought away to the distance required, and are connected up with light, rigid rods.

The engines of hoists are all of the short-stroke type. As they consume a large quantity of steam, and as quick running is essential, the passages must be of large area. The cylinders are placed either horizontally, or vertically, or diagonally. In many hoists they are attached directly to the boiler in a vertical position They are bolted to the base plate in horizontal types; in some vertical types they are bolted to standards attached to the base. In diagonal engines the cylinders are bolted to cheeks. But the diagonal position is seldom adopted now, excepting in some of the ships' deck winches. A considerable number of hoists with vertical engines are employed, but the horizontal position predominates in an overwhelming number of examples. And it is better that engines should be low down on the base plate,—the most favourable position for steady working. The single-cylinder type of engine suffers from the disadvantage of dead centres. Yet numbers of these are in use without link reversing gear, though ill adapted for frequent starting and slow movements. Usually link motion should be fitted alike to single and double engines, so that the load can be lowered, if desired, by them instead of by the brake. Generally, however, for moderate descents it is more convenient to lower by the latter, a method which is capable of very exact control.

Great differences in the working out

of details are found in hoisting engines, which, to an inexperienced eye, would not be obvious, and in some of these marked improvements have been made in recent years. More attention is given by the best makers to the durability of wearing surfaces. This is evident in the increased thicknesses of pistons, in the length of the crosshead and area of the surfaces, in the area of the crank-pin, and other details. In the best hoisting engines the flat-bar guides are less used than the bored ones cast in one with, or bolted to, the cylinder end, the latter affording larger bearing surfaces and central stresses. In the engines of one manufacturer the bearing of the circular crosshead in its slide is longer than the piston stroke, so long, in fact, that it always covers an oil-well, which is packed with absorbent material for lubricating both it and the guide. Counterbalancing is also an important matter in high-speed engines that mostly run without governors, as is also the lightening of reciprocating parts, such as pistons and valves. In one type the valves operate on a curved seat.



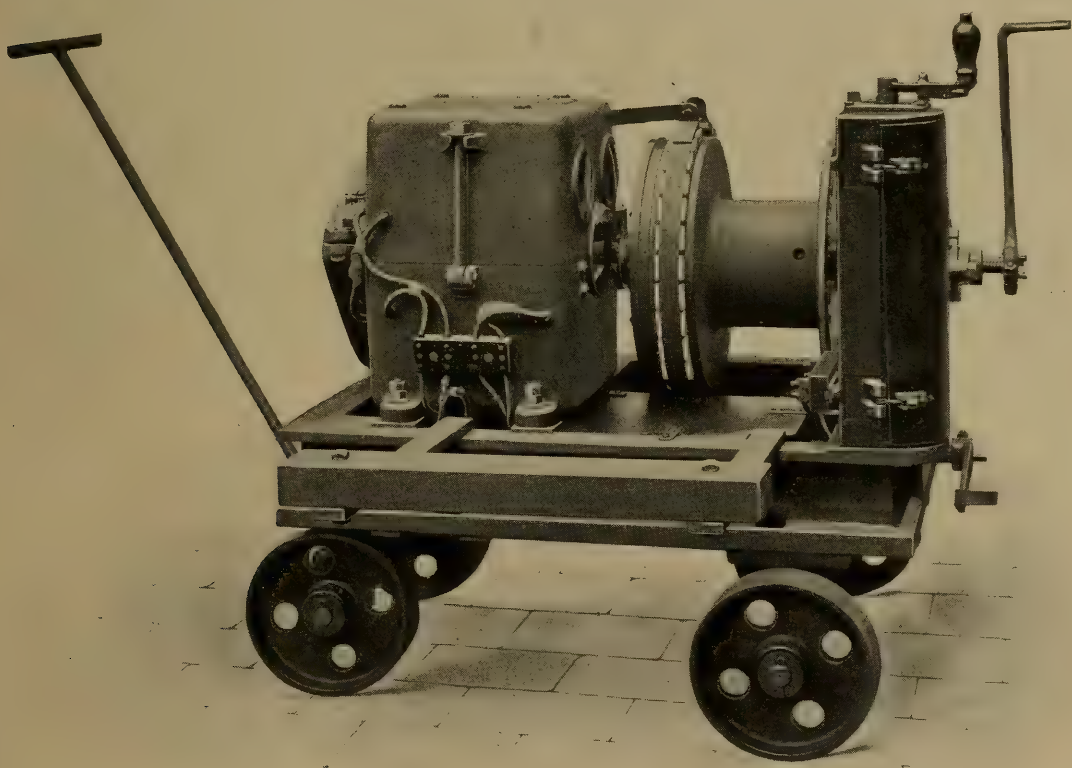
PORTABLE ELECTRIC DOCK HOIST BUILT BY THE LIDGERWOOD MFG. COMPANY

Hoisting engines are made with and without boilers, the latter class being supplied through steam pipes. The case for engines without a boiler is when one happens to be already installed, from which steam can be carried to the hoist. In tunnels also, where a steam boiler would be objectionable, hoists can be served with steam pipes, though in such situations compressed air is frequently used in preference. For dock work, hoists are conveniently placed at intervals,—permanently or portable,—and supplied with steam from a length of pipe, each using as much steam as is required, without having to fire up a boiler for a passing service.

The base-plates of hoisting engines are of cast iron, or wrought, or steel-plated. Either one embodies good practice, if proper proportioning is observed. Shrinkage strains in cast iron are avoidable, and a well-designed casting is then as good as one made in sectional steel or iron. For transshipment, it is usual to build the base in sections, bolted through reamered holes, and this can be provided for in either material.

For deep mines and long inclines the type of hoist in which the drum is grooved for wire rope is commonly used. In the standard form it is keyed on its shaft. It is of large diameter, and flanged rather deeply. Some of the largest of these hoists are driven by double spur gearing, one set at each end of the drum, which equalises the strains, and is a safeguard in case of teeth breaking,—a usual practice also in many cranes of large size. Many of the large drums have wooden lagging, which is grooved, as in those of iron. Some engines will wind 1600 feet of wire rope in a single lap. Lifting speeds are as high as 1000 feet or more a minute. It is desirable, as a rule, that wire rope should not make more than one lap round its drum, because the friction between the mounting coils tends to wear the edges. If a drum will not coil sufficient in one lap, it is better to increase its length. Often the barrels for large winding engines are of a composite character, being built of timber lagging, bolted round the rims of end castings which comprise a central boss and arms. These have been employed for many years about quarries for hauling stone up the inclines. They wear in time, but the lagging is easily renewed, and the cost is less than that of heavy cast drums.

A type of winding engine employed to a considerable extent in Great Britain is operated by a semi-portable boiler separate from the winding gear, situated either close by or at some distance off. A number of hoists have been made for use in London warehouses in which the cylinders oscillate, the piston-rod driving directly on to the drum. The base-plate is bolted to the wall, and the normal axis of the oscillating cylinders is vertical, a steam chest and valve placed between the pair of cylinders serving them both. They are made direct-acting, and also geared for high power. These are used chiefly for working warehouse cranes.



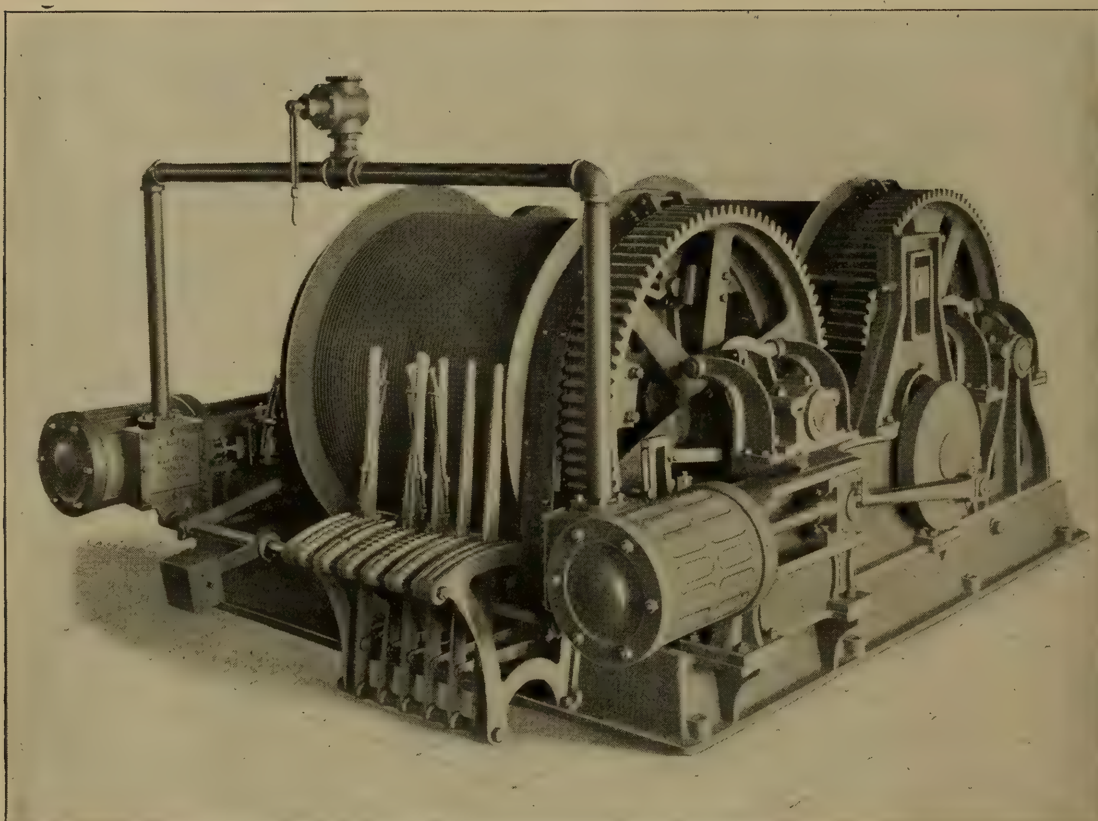
ANOTHER FORM OF LIDGERWOOD ELECTRIC DOCK HOIST

A belt-driven hoist by the Lidgerwood Company combines a double set of operations in one movement of a series of levers. The lever which actuates the friction drum is connected to

the brake lever, with the result that when these are moved downwards the drum is loose on its shaft, but the brake is applied, and either lowers the load or holds it on the drum at will. When the levers are raised the brake is taken off and the drum hoists the load. In the middle position the drum remains loose and the brake is off. Either one or two drums are used on a single bed-plate.

Small winches are used in which worm gear is substituted for spur gearing, in fitted with friction drums. Others also have two sets of bevel gear, by which, on the movement of a lever, speeds can be doubled.

Modifications of the hoisting engine are used for hauling at the end of wire ropes for handling coal in cars on cable railways. Another type handles coal in conveyors. These, unlike those for ordinary service, are fitted with governors. A special application of hoisting engines is that for the loading and unloading of coal with grabs or shovels.

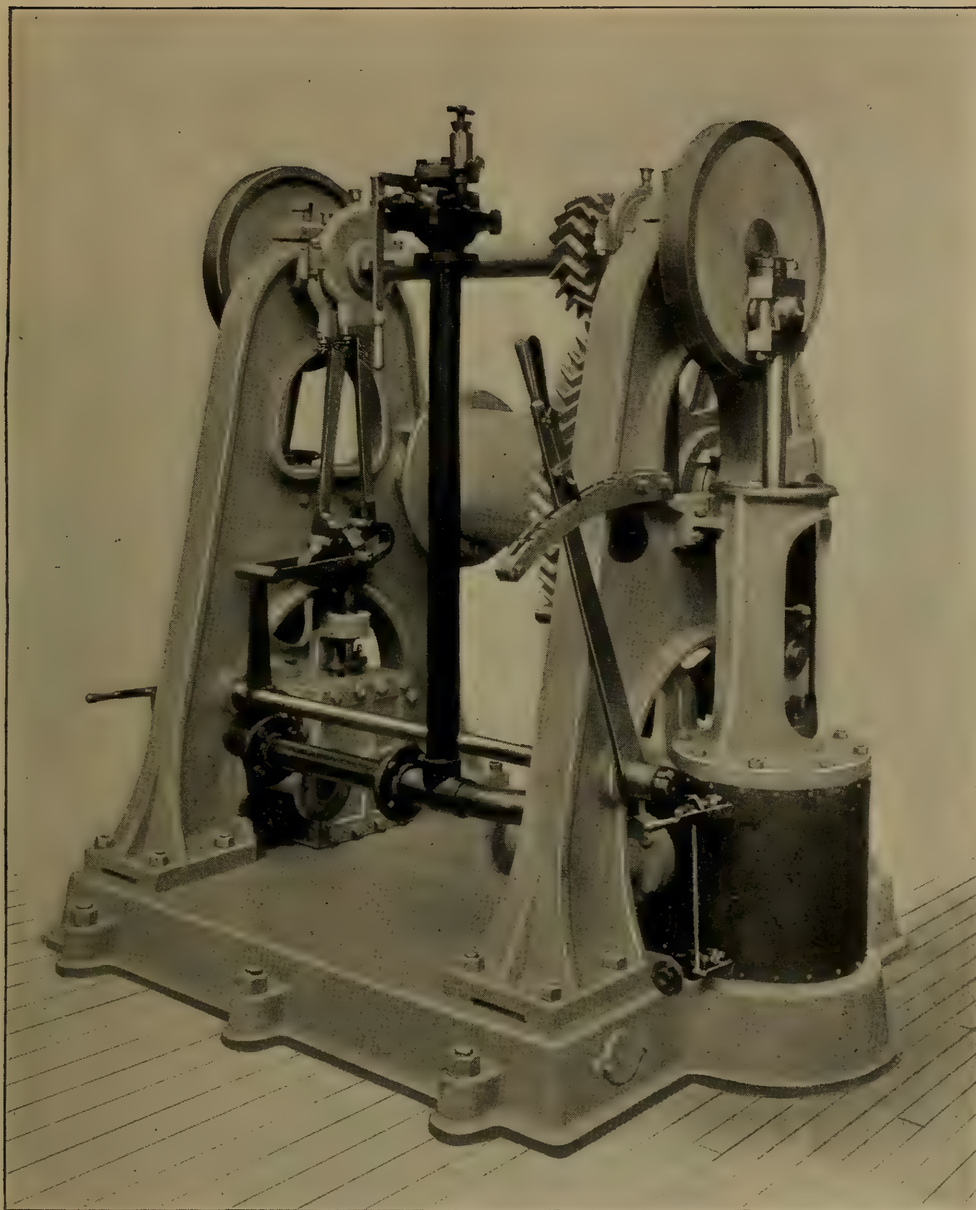


HOISTING ENGINE MADE BY THE EXETER MACHINE WORKS, PITTSTON, PA., U. S. A.

order to prevent the pull of the rope from overhauling the engines. These have either drums or winch heads, and the introduction of the worm gear necessitates placing the engines at right angles with the drums.

The old horse gear appears in a novel form in America. Hoists are made in which the drums are driven by a horse walking round at the end of a lever. Between this and the drum there is a system of bevel gearing. The loads are lifted by the horse-power, and lowered by the brake. They are made with single and double drums. Some are One American firm is making an attachment to these by which the weight of the shovel is automatically balanced at all points, so that the engine has to lift only the actual load without the weight of the shovel. This is effected by suspending a weight from a conical drum, the diameters in the grooves of which correspond with the diameters of the coils of flat link chain used on the drums.

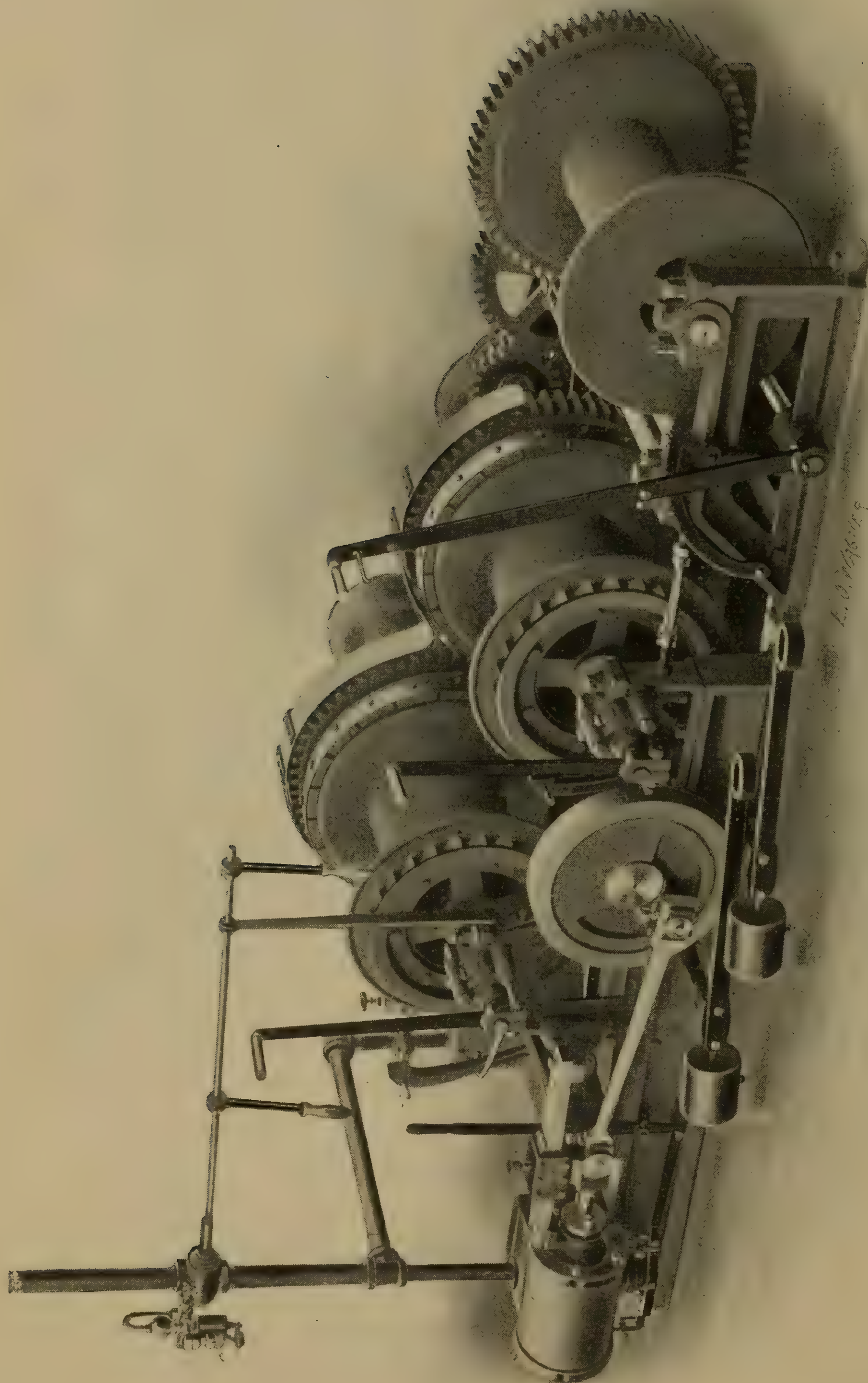
Five agents of haulage are in use,—ropes of hemp, and manilla, used chiefly for winch heads; chains for drums; wire ropes similarly employed; flat wire ropes



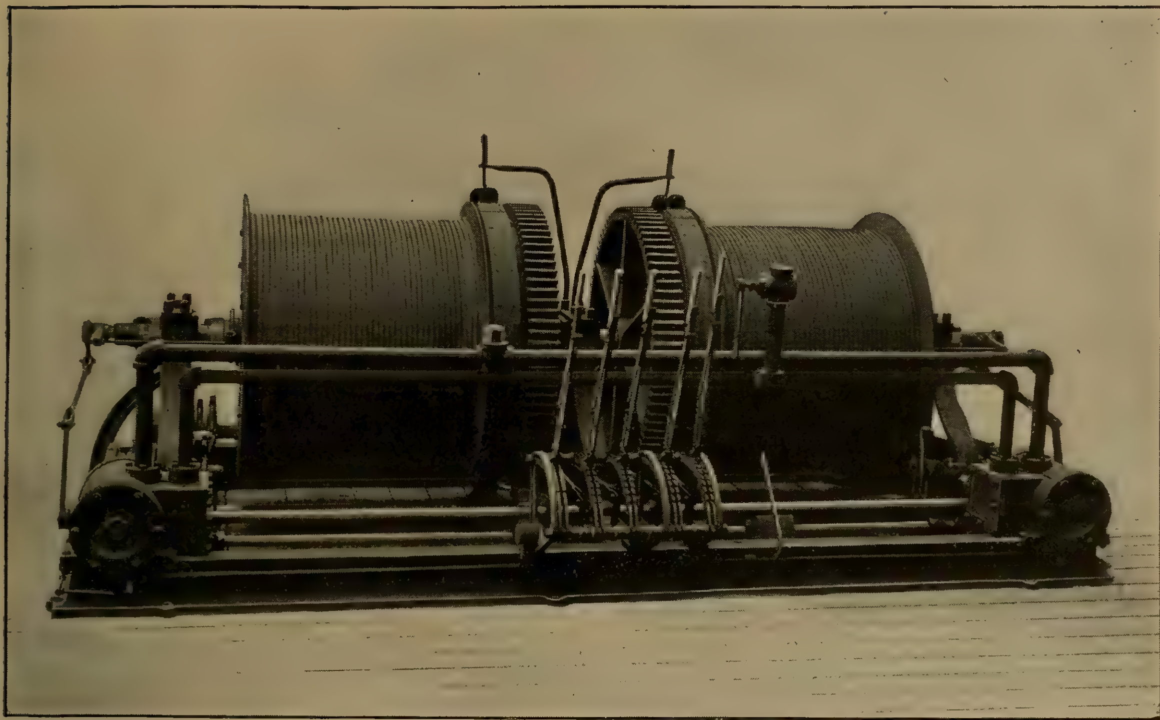
HOISTING ENGINE BUILT BY MESSRS. JOSEPH BOOTH & BROS., LTD., RODLAY, LEEDS, ENGLAND

for mines; and flat-link chain, or laminated chain, sometimes used for coal hoisting. There are advantages in each. Long manilla ropes are more easily handled than long wire ropes, because there is no trouble with kinks, as there may be in the latter. Wire rope is preferable for hoisting drums when it is wound in spiral grooves. Little can be said in favour of common link chains. The laminated chains are safe, if properly made, but they require a special drum.

Two relatively new agents promise well for the operation of hoisting engines,—oil and electricity. Each is much better adapted for certain situations than steam; in tunnels, and in out-of-the-way districts where fuel is costly they are of special utility. Where water power plants exist, conductors are easily carried to hoisting engines; if these are not available, oil may be. Electric hoists have not displaced the other types to any great extent yet. But electricity is an admirable motive power, and but for the cost of the electrical details it would have more quickly come into general use. A hoist is generally a rather cheap ma-



DOUBLE-DRUM HOISTING ENGINE, WITH BOOM-TURNING DEVICE, BUILT BY THE LAMBERT HOISTING ENGINE CO., NEWARK, N. J., U. S. A.



TANDEM-DRUM HOISTING ENGINE BUILT BY THE S. FLORY MFG. CO., BANGOR, PA., U. S. A.

chine, and the cost of motor, resistances, and brakes bears a larger proportion to the cost of the mechanical details of the hoist than they do to those of travellers or cranes. Another point is that compressed air is a powerful rival to electricity, and it already occupies the field. So many firms make air-compressing plant that the work is standardised, and the cost is less than that of electrical work.

But the same general arguments that apply in favour of the electrical driving of cranes apply also to hoists, and a self-contained hoist, carrying gears, motor, resistances, and brake on one framing of cast or wrought iron, is an ideal type.

THE ELECTRIC MOTOR FOR SPEED REGULATION

By Dr. Schuyler S. Wheeler

THAT an electric motor is useful chiefly because it affords a means more convenient than any other of running machinery at different speeds, or at an exceptionally steady speed, is a comparatively new idea, but it is spreading so rapidly that it attracts much attention. Electric power was originally introduced because of its economy, simplicity, and ability to bridge distance; but lately another virtue, heretofore comparatively unobserved, is being studied, or rather, its sponsors, finding that the world has grown to value it, chiefly on account of its use for regulation, are studying to produce more and greater results along this line.

The reason why the feature of regulation and control of speed is assuming this position of paramount importance compared with the other features, such as transmission economy, for example, is easily explained. The simplest pos-

sible form of an electric motor is the shunt-wound machine, and this, when connected with the ordinary electric lighting circuit of to-day, runs at a steady speed, drawing hardly any current until it is required to furnish power, and at that moment it consumes power only in proportion to the work done. If connected to a circuit of lower pressure, it will run equally well, but at lower speed. If it is required to make extra effort, as in starting machinery, it will furnish up to five times its full power without trouble.

When running free, if its speed is increased by the application of external power, as by a belt, it becomes a dynamo and pumps current into the line; this, in turn, throws work upon the machine and tends to slow it down. The machine is, therefore, in itself a factor, tending to the preservation of constancy of speed and to the preservation of constancy in the pressure on the circuit, its momentum tending to steady the pressure on circuits which fluctuate, and it is ideal in its simplicity, having absolutely no governing or accessory parts.

To obtain any speed desired, it is only necessary to supply the armature of the motor from a circuit of lower or higher pressure to correspond, when the motor will run slow or fast in nearly exact proportion to the pressure supplied. This principle is the foundation of the best methods of to-day for speed variation, whether it is put into effect by resistances used in connection with the machine for cutting down the pressure, or by the use of different circuits supplying different original pressures. The ability to do at once all of these things is absolutely without parallel or comparison in any other kind of prime mover, and explanations of the operation of the electric motor are consequently attended with a little difficulty, because there is a lack of points of similarity with other engines.

A steam engine, for example, will stall when its ordinary capacity is exceeded, and it is governed by external apparatus which often becomes deranged, and which may act too late to prevent fluctuations in the speed; again, the operation of the engine is entirely different from that of the motor in that it is not capable of reversing its action under fluctuating conditions. For example, if for any reason the boiler pressure runs low or the engine speed runs high, the engine will not pump steam into the boiler and assist in maintaining the steadiness of the system; again, the engine cannot have its speed changed at any moment when a different speed is desired, nor operate with equal economy at different speeds.

The shunt-wound motor runs at practically constant speed under all loads, and if closer uniformity of speed is desired it can be arranged to run within any desired limits of variation by setting the brushes in a position shifted slightly from their usual place, or by adding to the field winding a few turns, connected in series with the armature, and reversed in comparison with the main winding. Either of these arrangements causes the motor to speed up under load, and the extent of this action may be adjusted to equal precisely the tendency ordinarily met of slowing down under load.

When variations of speed are desired they are obtained by the use of different pressures to run the motor, the speed in each case corresponding very closely to the pressure employed. These pressure changes are made either by running the current through a resistance or rheostat, which cuts it down, but interferes with the constancy of speed; by adjusting the generating dynamo so as to yield a high or low pressure, or by the use of multiple circuits to give different pressures. When the last-mentioned plan is used, a number of conducting wires, each connected to a separate source, so that each wire will give a different pressure, are run around the building to each motor. This system may be compared with the method of writing music, and the several wires to the bars of the staff. The speed of each motor will be high or low according to the bar to which it is connected, in the same way that the musical notes are high or low. The method, however, is limited to cases in which the

motors are not located very far apart.

The starting up of motors is a part of this same subject, being a case of control for brief periods, and as they can be started and stopped so easily and quickly, they have, again, a great advantage. The operations necessary are the same as those for speed control. The motor's speed is regulated (controlled) from slow to fast at short intervals sufficient to allow the connected machinery to be set in motion without violence.

While the above is an outline of the more important principles underlying the subject, and is the basis of practically all of the commercial applications of motors, there are really nine different methods by which the speed of a motor may be varied:—

1.—By throttling or inserting resistance in the armature circuit. 2.—By changing the circuits within the machine. 3.—By changing the magnetic parts of the machine. 4.—By varying the strength of the field electrically. 5.—By varying the time average during which the current is applied to the motor. 6.—By rotating the commutator brushes. 7.—By the use of a number of circuits, each supplying a different potential. 8.—By changing, at the source, the pressure which operates the motor. 9.—By adding to or reducing the pressure from the source by the use of an auxiliary pressure.

These are mentioned in their approximate order of invention. Several have not been found useful, and are, therefore, of scientific interest only. There are numerous ways in which each may be carried out, and the devices resulting from combining two or more, several of which combinations are extensively used, are almost innumerable, and their description would not be appropriate here.

The purpose of this article is to draw attention to the following leading facts pertaining to the general subject:—

First.—The electric motor's regulation and control are the most valuable of all its good attributes.

Second.—It is unique and remarkable in the accuracy, scope, and adjustability of its regulation. It maintains a speed which is nearly constant and is not deranged by great overloads. It may be adjusted to run with a constancy of speed within any limits of precision, and its action swings about this fixed speed as a centre, its activity increasing as a motor if it is slowed down by heavy load, and becoming that of a dynamo and reversing the demand for current if speeded up by the application of extra power.

Third.—It achieves this remarkable regulation when made in the simplest form and without any governor, valve or other apparatus.

Current Topics

Good judgment and common sense are matters of primary importance in drawing up an engineering specification. The purpose of such a document may be said, very briefly, to be the attaining of a certain result for the least amount of money compatible with proper execution of the work involved; but, curiously enough, the stipulations sometimes made in a specification, and with the best intentions, too, defeat that very object. An excellent illustration of this point was given recently by Colonel Denny, of the well-known Dumbarton firm of shipbuilders, in his presidential address to the Institute of Marine Engineers. In this he told of a specification for an engine received by his firm some time ago which was so overloaded with what might be called fads, or, at any rate, with what might quite well have been dispensed with, and consequently contained so many names of persons who were to supply particular pieces, that the price was enormously increased. The engine was one which would have cost £70,000 if his firm had been allowed to design it, and supply it with an absolute guarantee that the work would be just as well done as by the other. The additions referred to and the naming of people to supply various materials, however, brought the price up to £90,000, and threw all the responsibility not upon the engine builder, but upon the engineer who drew the specification, and who had no right to have such a responsibility upon him. The immediate procedure of an engine builder when he gets such a specification is to communicate, at once, with every one of those specially named, stating that their name is in this specification to furnish a certain part, and asking for their price. Probably nineteen or twenty other firms bidding for the job do the same thing, and the result is that it is unwisely impressed upon those makers of specialties that their product must go into the work. And what do they do? Very naturally, make their price a first-rate paying price. In the case specially considered by Colonel Denny there was a difference of about 100 per cent. between the prices of several of the articles called for and those at which his firm could have supplied something equally good. The lesson is obvious.

In West Australia the absence of running water renders unavailable the cradle and the sluice-box of ordinary placer-mining for gold, with the result

that the prospector has learnt, intuitively, to utilise the agency which he sees incessantly at work in nature around him. Wind replaces water. The method is simple. As told by Mr. T. A. Rickard a short time ago, in a paper read before the American Institute of Mining Engineers, the operator has two pans, or dishes, as the Australian calls them. One of these he places on the ground, empty, while into the other he puts a shovelful of the "dirt," that is, the sandy detritus containing the gold. The material is shaken up so as to bring the big lumps on top, and then, resting the pan on one knee and holding it with his left hand, he uses the right hand to skim off the coarse particles, as shown in the lower sketch on this page. Then, standing erect and facing at right angles to the direction of the wind, he slowly empties the full pan into the empty one at his feet, as shown in the upper one of the illustrations. As the stream of dry dirt falls, the wind selects the fine and blows it in a cloud of dust to leeward. The operation is then reversed, the pan which has just been emptied being placed on the ground so as to receive the contents of the other. This is repeated three or four times, according to the degree of concentration effected. In a strong breeze one operation may prove sufficient. To prevent the loss of the fine gold which is sometimes carried away with the dust, it is customary to spread a piece of canvas on the ground, one end being placed under the pan and the other extending to leeward. The next stage is to further winnow the material by tossing it up and down in the pan; the latter is held slanting forward, and is jerked so as to throw the dirt from the front to the back of the pan. The light particles are separated, as chaff is driven from grain. Then, giving the dish a vanning movement, the prospector again removes the coarser particles that come to the surface by skimming them off with his hand. There now remains about half a pint of material, and this is diminished by panning, just as in water, the dry particles having a mobility permitting this method of treatment. Finally, he drops on his knee, and, holding the pan so that it is tilted forward, he raises it up to his mouth and uses the breath of his lungs to complete the process. The particles of gold are seen fringing the edge of the iron sand. If the yield consist of only a few minute particles, he puts his moist thumb on them, and so transfers them to his pocket; but if there be any coarse pieces,—nuggets,—they are put into the leather wallet attached to his belt. Owing to the perfect dryness of the dirt and the heat imparted to the surface of the iron pan under a tropical sun, the material behaves with much of the mobility which it would have if water and not air were the vehicle employed.

SKIMMING OFF COARSE PARTICLES

DRY BLOWING

TROUBLE with gas and gasoline engines working at high altitudes has prompted an item in *The Gas-Engine Magazine* to the effect that, as ordinarily sent out, such engines have air inlets too small and compression spaces too large for satisfactory work in a rarified atmosphere. In other words, when an engine is intended for high altitudes it should have a larger air-inlet and a smaller compression space than when the same engine is to work at sea-level. It is hardly worth while to make these changes for altitudes of less than 5000

feet, but for that altitude, and for those that exceed it, the engine should have a plate attached either to the piston or to the cylinder head in order to reduce the compression space. It should also be remembered that gasoline at high altitudes evaporates at a much lower temperature than at the sea-level, and it would be well, therefore, to use the heavier grades.

WITH the growing value of ground space, the tendency of modern buildings has been to extend upwards rather than to spread out, and the tall American, aptly termed "sky-scraper," has become its most striking example. With it, too, has come the higher development of the elevator, or lift, as a means of transportation from floor to floor, without which the tall building would have lost much of its attractiveness as a business proposition. Now that this type of structure has become firmly established for business office and dwelling purposes, at least in the United States, and even for manufacturing uses, it is interesting to note that the tall building principle has been advocated as well in the erection of churches. Many of the existing church edifices are large and costly structures, on expensive sites, and yet there cannot be called to mind a single case where a church has availed itself of the possibilities of elevator service and has departed much from time-honoured custom in the matter of general lay-out. There appears to be no good reason why an elevator should not be used in a church, to increase the value of a gallery, for example, which usually is a neglected and unpopular part; or to be the means of furnishing additional room facilities without the expense of more ground space and separate structures, and that, too, without impairing the churchly character of the architecture. There would seem to be in this something worth thinking about by architects and church communities.

IN the latest annual report of the Boston Manufacturers' Mutual Fire Insurance Company reference is made to the objection to the use of some of the earlier forms of portable fire extinguishers in main works and factories on the score that any apparatus which required time for its adjustment had, in some cases, increased the fire loss by delay instead of prevented it. The earlier type of fire extinguisher, however, has been displaced by better ones which can be used in about as simple a manner as a bucket of water, the only adjustment necessary before use being a simple reversal of its position. But withal, the fact, noted in these pages several years ago, still holds good, that open pails and buckets, filled with water, have not yet been surpassed in efficiency as "first aids" in fire-fighting, and in the report above mentioned the statement is repeated that more fires are annually put out by such pails and buckets than by all other appliances put together.

ONE trouble with water pails for fire protection always has been that, while they might be provided abundantly enough in places where they were likely to be of service, the water was apt to be wanting at a critical time, either because of evaporation, or its use by some borrower, and failure to replenish the supply. It seems worth while, therefore, to reprint from an earlier issue of this magazine the following particulars of the arrangement adopted by the superintendent of a certain large mill with the object of overcoming this difficulty. The hooks from which the pails were suspended were fitted up with pieces of spring steel strong enough to lift the pail when nearly empty, but not sufficiently so to lift a full pail. Just over each spring, in such a position as to be out of the way of the handle of the pail, was set a metal point, connected with a wire from an open-circuit electric battery. So long as the pails were full, their weight, when hung on their hooks, kept the springs down, but as soon as one was removed, or lost a considerable portion of its contents by evaporation

or otherwise, the spring on its hook would rise, come in contact with the metal point, thus close the battery circuit and ring a bell in the manager's office, at the same time showing on an annunciator where the trouble was. As the bell continued to ring until the weight of the delinquent pail was restored, it was impossible to disregard the summons, and no further reason was found in that establishment to complain of the condition of the fire buckets.

JAMES GAYLEY

MANAGING DIRECTOR OF THE CARNEGIE STEEL COMPANY, LTD.

A BIOGRAPHICAL SKETCH

By John Birkinbine

MR. JAMES GAYLEY, of Pittsburgh, managing director of the Carnegie Steel Company, made his *début* as a metallurgist about twenty-four years ago, when he graduated from Lafayette College with the degree of mining engineer.

His start in business was in 1877 as chemist for the Crane Iron Works, at Catasauqua, Pennsylvania, with a salary of $500 per annum

In 1900 he directed the mining, purchasing, shipping, and handling of more iron ore, and probably assembled a bulk of ore, fuel, and flux at his company's furnaces greater than any one person had done before. A modern blast furnace consumes from one to two thousand tons of raw material daily. To supply the requirements of the year 1901 of the score of blast furnaces controlled by the Carnegie Steel Company four million tons of iron and manganese ores must be mined and delivered.

To appreciate this quantity, the facts may be recalled that all the iron ore mines in the United States did not produce four million tons until the year 1872, and the first annual record of the Lake Superior region which exceeded this quantity was in 1887, while Sweden, Austria Hungary, or Belgium, all iron-producing countries, have never reported so large an output of iron ore in one year as the blast furnaces of the Carnegie Steel Company demand.

Most of the iron ores used are of special composition, in which the relation of iron to phosphorus is important. They are obtained from mines owned by interests affiliated with, and under the general supervision of, the company, carried 15 to 90 miles by rail, then 600 to 900 miles by water, and finally 135 miles by rail. The manganese ores are brought by vessels from various parts of the world, from Russia, Turkey, Chili, Brazil, Cuba, and Japan, and are hauled by rail over the Allegheny Mountains to the company's blast furnaces. The limited season for lake shipments and the distances from which the manganese ores are brought require that enormous stocks, aggregating two million tons, must be accumulated on the receiving docks or at the furnaces of the Carnegie Steel Company, and the distribution of these to the various plants, so as to reduce stocking charges, and the handling to a minimum is a detail of no mean importance.

One of the duties of Director Gayley is to provide the raw materials for the Carnegie furnaces, and his life work has eminently fitted him for giving special attention to the mining, assembling, transportation, and distribution of the ores, for he judges them with knowl-

edge gained from years devoted to their analysis and practical use.

His three years' service with the Crane Company was followed by an engagement with the Missouri Furnace Company, at St. Louis, where conscientious work in the laboratory resulted in his advancement to the position of superintendent of the works. From St. Louis Mr. Gayley returned East to manage the blast furnaces of the E. & G. Brooke Iron Company, at Birdsboro, Pa.

When, in 1885, Mr. Gayley was placed in charge of the blast furnaces of the Edgar Thomson Steel Works, he became a factor in the generous rivalry for pre-eminence in blast furnace practice, which was then pronounced, and which still exists between the Illinois Steel Company and other large plants and the Carnegie plants. Fuel being an expensive component of pig iron, the practice at Chicago was to run with small blast volume, while at Pittsburgh, where fuel was cheap, the reverse was the case. To Mr. Gayley much of the credit is due for the practice which has secured large output and low fuel consumption with moderate volumes of blast. It is no reflection upon other progressive blast furnace managers to assert that Mr. Gayley's practice at the Edgar Thomson plant, considering the available mechanical appliances, the output based upon the cubical capacity of furnaces, and the tonnage made from one lining, in combination with low fuel consumption, has not been surpassed.

From the head of the blast furnace department Mr. Gayley was advanced to the management of the entire Edgar Thomson plant, and from there he was transferred to the general office, where he has since remained and serves as a managing director of the Carnegie Steel Company.

Recognising the possible economies in handling material at the blast furnaces, Mr. Gayley inaugurated a system of bins at the Edgar Thomson plant, and as an advocate of all such labour-saving devices, he is responsible for the introduction of many appliances at blast furnaces and at ore docks. He also is credited with making the first installation of compound condensing blowing engines in connection with American blast furnaces.

Among Mr. Gayley's inventions which have contributed in advancing the iron and steel industry are a bronze cooling plate for blast furnace walls, which is widely used, and an auxiliary casting stand for Bessemer steel plants, which holds the steel ladle while the heat is being poured, and relieves the crane from that work. Two vessels thus make the output formerly produced from the four.

His contributions to the literature of iron metallurgy have been of such character as to give him an enviable reputation in foreign lands, as well as in his native country.

As the son of a clergyman, it is probable that he received his father's best legacy,—a good education. That he has made use of the advantages thus given him is evidenced by his rapid advancement, and it is to Mr. Gayley's credit that he shares with his *alma mater* the substantial results of his labours by erecting a fully equipped chemical and metallurgical laboratory for Lafayette College.

Mr. Gayley is a member of the American Institute of Mining Engineers, of the Iron and Steel Institute of Great Britain, and other societies. He is a close student and a hard worker. It is a gratification to his many friends that his application and devotion have been recognised by the company with which he is connected, and in his advancement the young men who are now at work in chemical laboratories, or who manage blast furnaces, can find encouragement for conscientious attention to details and close application to the duties assigned to them.

Manufacturing News.

ONE of the most important movements in the iron trade, and one that will have a far reaching effect, is that recently made by the Carnegie Steel Company, of Pittsburgh, in chartering four boats, *Leafield*, *Theano*, *Pliki*, and *Monks Haven*, to be used in transportating cargoes of steel from their mills at Duquesne, Bessemer, and Homestead, to foreign ports. Each of these boats will be loaded with about 1000 tons of steel, and will sail from Conneaut Harbour to Montreal, via the Welland Canal and St. Lawrence River. The steel will be hauled from the mills of the Carnegie Steel Company in the Pittsburgh district to Conneaut Harbour by the Pittsburgh, Bessemer & Lake Erie Railroad, a distance of 153 miles. At Conneaut Harbour the four boats above named will be loaded each with about 1000 tons, and in addition each boat will have a tow of about 1500 tons of wood pulp, which they will ship when they get into deep water at Montreal. The steel cargoes will load the boats down to about 14 feet, and the water in Welland Canal is not deep enough to allow them to load the wood pulp until Montreal is reached. The distance from Conneaut to Montreal is 600 miles, and the time consumed will be about six days. The four vessels named above, when they reach the other side, will engage in British coastwise trade, and will not return to this country until next spring at least, when navigation on the Welland Canal is resumed. This is but the beginning of a movement by the Carnegie Steel Company, and, in fact, other large steel interests, to provide their own means of transportation of their steel products to foreign ports. It will be recalled that the American Steel and Wire Company are now engaged in building several boats to be used in foreign trade, and it is not improbable that the Carnegie Steel Company will before long also place contracts for the building of large boats to cross the ocean with their products. It means, further, that American steel makers realize that foreign trade must be had in order to take care of our surplus product, and that transportation facilities will probably have to be provided by themselves. So far, the railroads have refused to grant any relief to iron and steel makers in the way of making low freight rates on iron and steel for export, but from the initiative movement taken by the Carnegie Steel Company, it would seem that the difficulty now existing on account of high

Carnegie Steel in Foreign Markets

freight charges can probably be overcome without the assistance of the railroads.

New Ocean Racers

THE contest of speed and size among transatlantic steamship lines is to be carried on still further by the North German Lloyd Company, who have under construction two new vessels which they expect to eclipse the performance of their present champion, the *Kaiser Wilhelm der Grosse*, and, if possible, that of the Hamburg-American liner *Deutschland*. They are being built at the Vulcan Works at Stettin, and are to be called the *Kaiser Wilhelm II.* and the *Kron Prinz Wilhelm*. Speed is to be specially considered in the building of the last-named vessel, which is expected to sustain a rate of about 24 knots across the Atlantic. The *Kaiser Wilhelm II.* will be 706 feet long, or a little longer than the *Oceanic*, about 20 feet longer than the *Deutschland*, and 60 feet longer than the *Kaiser Wilhelm der Grosse*. She will have 70 feet beam, a tonnage of 15,000, and 33,000 horse-power. Both vessels are to be ready for service in a year's time.

The Largest Springs Ever Made

WHAT may be considered a remarkable set of springs has been produced by the Tuthill Spring Company, Chicago. For an autotruck Mr. Tuthill was called upon to manufacture a set of springs having a capacity of 45,000 pounds. After careful calculation, a set of four elliptic and two relief springs of the following dimensions were turned out: Elliptic springs of the highest grade steel, 3½ inches wide; eighteen plates top and bottom; two plates ⅜ inches thick, remainder, 5-16 inches; 41¾ inches long, 2 feet high; 1 foot open inside; relief springs of the same material, 3½ inches wide; one with twenty plates, fourteen of which are ½ inch in thickness; remainder, ⅜ inch, making combined thickness 9¼ inches; 47 inches long, inside arch, 4⅞ inches; the other relief spring has twenty-eight leaves; combined thickness, 12⅝ inches; arch, 3⅛ inches. To the practical carriage and waggon maker these dimensions tell a story of a really wonderful set of springs in size and strength.

New Trade Catalogues

FOR years past catalogue-making in the United States could have been very properly classed with what might be called one of the fine arts. Nowhere else did trade publications reach so high a standard of excellence, and it is only within very recent years that foreign manufacturers have found it expedient, from a business point of view, to emulate American firms in this respect.

Two admirable recent examples of American trade catalogue art,— indeed, they seem more worthy of the name of text-book,—are the publications issued by the Brown Hoisting and Conveying Machine Company, of Cleveland, Ohio, and the Niles Tool Works Company, of Hamilton, Ohio. Both of these are full of interesting and valuable data and illustrations of the highest class.

The Brown Company, as is well known, are engineers, designers, and manufacturers of complete plants for the rapid and economic handling of material of all kinds, and in their publication they show in an elaborate manner some of the more important installations which they have thus far put up. The reading matter, of course, helps to explain much about their work, but the illustrations form the bulk of the volume and tell their own stories in an attractive and instructive way.

The Niles Tool Works catalogue is printed in three languages, English, French, and German. This feature appears to have been prompted by the Paris Exposition and the large display which the company have there. The various heavy machine tools made by the company are illustrated by excellent half-tones, printed on heavy paper, and the whole collection affords an interest-

ing object lesson of the diversity of machine-tool outfits which the company is prepared to supply.

Both of the publications are substantially bound, the one in cloth and the other in full morocco, and will make valuable library additions.

STILL another catalogue, which is in every way worthy of the praise given to the two just mentioned, is the one recently issued by the Baldwin Locomotive Works, of Philadelphia, and devoted to narrow-gauge locomotives. It is a substantial, cloth-bound volume of 452 pages, profusely illustrated both with half-tone and line-work cuts, and, in addition to the purely descriptive data, contains a very interesting history of the Baldwin Works.

WHAT is virtually a little text-book on pumps for all purposes has been issued by the Deming Company, of Salem, Ohio. It is bound in flexible cloth covers, and comprises 270 pages of useful and interesting information Not only pumps, but also pump fittings and accessories of all kinds, such as hose, brass goods in the shape of cocks and valves, and wrought-iron pipe and pipe fittings and tools are included in the material. The available sizes and prices of the various types of pumps are given in every instance, and there is also a useful chapter entitled "Information Concerning Pumps," which is full of facts, figures, and formulæ.

PLEASURE craft, both sail and motor-driven, are illustrated and described in an interesting booklet turned out by the Truscott Boat Manufacturing Company, of St. Joseph, Mich. It is full of matter that ought to be interesting to lovers of aquatic pleasures, special attention being given to power launches which are driven by gasoline motors of special Truscott design. Complete tables of sizes and prices are given, the latter being a very desirable and important, though frequently neglected, adjunct of trade catalogue particulars.

CHUCKS of all kinds are illustrated and described in a new catalogue by the Skinner Chuck Company, of New Britain, Conn. Since the publication of the company's last catalogue, two years ago, they have added to their list a line of lathe face plates with adjustable jaws, and have also made a number of improvements in their different patterns of lathe chucks. These are very well set forth in the publication in question.

THE B. F. Sturtevant Company, of Boston, are sending out a new edition of their planing mill exhauster catalogue. It is a neatly gotten-up booklet, and illustrates and describes very fully the several types of steel plate exhausters made by them. The concluding pages are given up to tables of air pressures corresponding to various heights of water in inches, the pressure and horse-power lost by friction of air in pipes, and other data of allied interest.

PLANERS form the subject of an attractive little pamphlet by the Betts Machine Company, of Wilmington, Del. Eight different styles are illustrated, and descriptive particulars are given of several more. The illustrations are well executed half-tones, and help to give a good idea of the character of the different designs.

THE American Blower Company, of Detroit, Mich., are sending out a neat booklet devoted to their several types of hot blast apparatus for lumber drying and the heating of manufacturing establishments. It is profusely illustrated, and gives a varied lot of information directly relating to the subjects under consideration.

ELECTRIC mine locomotives form the subject of a new catalogue which has just been issued by the General Electric Company, of Schenectady, N. Y. It is fully illustrated, showing the various types of electrical mine locomotives turned out by the company and some of their principal parts, and incidentally gives a lot of valuable information on electric coal-mining plant, such as mine station equipment, cost of haulage, transmission and distribution underground, and other similar data.

THE American Turret Lathe Company, of Wilmington, Del., have issued a little pamphlet entitled, "Three Points of View," which is devoted to the turret lathes made by them. The growing importance of turret lathes in machine-shop practice lends a special interest to literature of this kind, detailing the possibilities of this class of machine tool.

"THE Diamond Drill of To-day" is treated of at some length in a new publication brought out by the American Diamond Rock Drill Company, of New York. For all mine-testing and prospecting work the diamond drill is at the present time invaluable, and to prospective users of it the general description of the drills made by this company and of their special features, presented in this catalogue, will prove of interest. It comprises a large number of illustrations, and valuable data as well.

THE H. W. Johns Manufacturing Company, of New York, have brought out a little pamphlet devoted to their asbesto-metallic and cloth-wound packings. It tells what the different kinds of packings handled by them are made of, and gives illustrations and other matter of interest pertaining to them.

THE Dobbie Foundry and Machine Company, of Niagara Falls, have issued a new and attractive catalogue devoted to their Niagara shaking grate and what they term their Niagara automatic smoke burner for steam boiler furnaces. It is profusely and attractively illustrated, setting forth the construction and manner of operation of the devices in question, and, in addition, has a steam and an electrical department in which valuable data are given for the guidance of engineers, and firemen, and dynamo tenders.

GASOLINE engine hoists and air compressors are treated in two new catalogues published by Messrs. Fairbanks, Morse & Co., of Chicago. They are very attractive specimens of their kind, and the illustrations are very finely executed half-tones, giving a number of examples of the two particular uses of gasoline engines under consideration.

SPRINGS form the subject of a new catalogue brought out by the American Steel and Wire Company, of New York. There are in it extension and compression springs, torsion and flat springs, springs of all kinds and for all kinds of uses, and full particulars are given with the various illustrations. These are half-tones, and excellently represent the different types considered.

THE American Bridge Company have commenced making large shipments on account of the steel work for the subway in New York City. Already about 2000 tons have been shipped, and the material is now being sent in at the rate of about 100 tons per day. The total contract comprises about 80,000 tons of structural material, and is being manufactured at the Keystone plant of the American Bridge Company.

Manufacturing News

Trusts in the Iron Industry

THOSE who are, or pretend to be, opposed to the so-called "trusts" or industrial consolidations often take a good deal of trouble to exaggerate the power of such institutions. Their cue, as *The Iron Age* says in a recent issue, is to frighten the public with visions of grasping monopolies who throttle the consumer with one fist and shake labour into slavish submission with the other. The iron industry comes in for its share of attention as one in which the number of these monopolies is particularly large,— although the eloquent guardians of the human race fail to observe that their logic must be somewhat at fault when they apply the title of monopolies to a number of concerns in one industry. We are told almost in one breath that the "trusts" are robbing the public by extortionate prices and that the fact that they have closed down many plants is evidence that the much-vaunted prosperity does not exist. As a matter of fact, if there is any cause for uneasiness in the iron trade as to the future, it is that competition with the great consolidations has been increasing and threatens the stability of the trade. That competition may be classified roughly as being external and internal. The former word may be used to designate those plants which have been started as entirely new enterprises, to share with existing consolidations the liberal profits which they are shown to have earned by their published reports. The "internal" competition is that which comes from the invasion of the territory of one consolidation by another. The sharp drop in prices in the American iron market during the last few months has probably nipped in the bud many enterprises projected to worry one or the other consolidation into a purchase of the competing plant at fancy figures. In some instances "outside" undertakings have been started by men who had sold out at a handsome profit to the very organisation which they attack. It may be said that this is inevitable because there are no means to tie down retiring interests. In this way some very ambitious and, let it be added, some, to the "trusts," very dangerous enterprises have been started.

But what looks like much more disquieting competition in the American iron and steel industries is that which is developing among the different "trusts" themselves. With one ex-

ception, all those large consolidations which did not already go back to the ore have striven to secure independence of the great steel-making concerns by acquiring ore and coal property, and developing furnace and steel capacity. In that way they have deprived, or threaten to deprive, the large steel makers of an outlet for a considerable part of their tonnage. The result is that threats to invade this or that field have been numerous, and in some instances are being carried into effect. Competition thus develops which is on a very different basis from that between a moderate-sized outsider and a huge consolidation. It becomes a strife between the giants themselves, in which heroic measures are often and suddenly taken. That such developments are not calculated to do the iron industry any good in the long run is evident, because they lead to additions to capacity which are wholly unnecessary. Even without any new comers the productive capacity is growing simply through the fact that every consolidated group is remodeling and concentrating superannuated plant and is making improvements. It really looks as though competition, far from being done away with, may become fiercer at times than it ever has been. The corrective to the dangers of the fusion of interests during the past eighteen months is being applied even more quickly than has been thought probable. The more arbitrary the "trust" management, the more rapid apparently has been the advent of the dangerous rival.

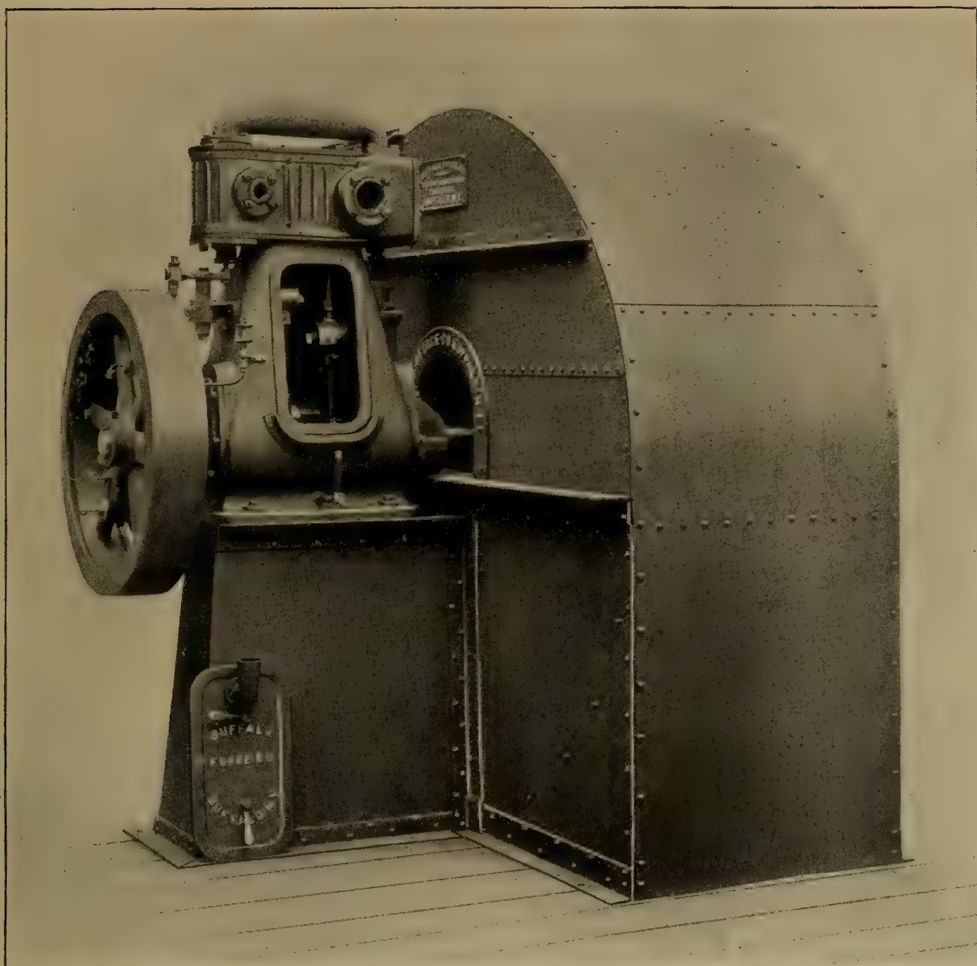
A Special Mechanical Induced Draught Fan

THE illustration on the page opposite shows a special steel-plate fan, designed by the Buffalo Forge Company, of Buffalo, N. Y., for mechanical induced draught. The fan is one of two similar pieces of apparatus which together form a duplex induced draught plant installed in a large electric power plant of Northern England. Each fan is capable of handling the gases from four Galloway boilers, each 8 feet 6 inches in diameter and 28 feet long, with a grate area of 48 square feet. The capacity of the fans was calculated on a basis of a coal consumption of twenty pounds per square foot of grate surface, using a Durham coal locally known as "Small Bean." The steam pressure carried is about one hundred and forty pounds per square inch. These boilers are arranged in conjunction with two economisers so that the furnace gases are cooled to about 450 degrees Fahr.

The fans in this instance are 100 inches in diameter, and are driven at a speed of about four hundred revolutions per minute, equivalent to a pressure of two inches of water at the fan outlet. All gaseous products of combustion from the boilers, after passing through the economisers, are drawn to the fans, which are situated on a platform above the boilers, and are discharged upwards into the short steel stack.

The fans themselves are of the full-housing, up-blast, steel-plate construction, rigidly braced with angle irons. The fan wheel is built of steel-plate blades, bolted to wrought iron spider arms, and provided with conical side pieces to lend rigidity to the whole. In order to insure cool running while handling the hot gases for long periods, the fan-wheel shaft is supported in a water-cooled bearing, and, in addition, the main bearing of the engine on the side next the fan is likewise provided with a water-cooling device.

The blast wheel, which is overhung, is driven by a Buffalo vertical, cross-compound engine, supported upon a sheet-steel base integral with the fan. The engine is designed with cylinders four and six inches in diameter, with a common stroke of five inches, and, running non-condensing on a steam pressure of 130 pounds per square inch, develops 17 horse-power. The various rotating and reciprocating parts work within the cast iron frame, which, by the addition of a removable side plate, is rendered oil-tight and dustproof. The engine is arranged to run in oil, and in this way all the bearing surfaces within the frame are well supplied with lubricant. The low-pressure cylinder



A STEAM-DRIVEN FAN FOR MECHANICAL DRAUGHT, BUILT BY THE BUFFALO FORGE CO., BUFFALO, N. Y.

is fitted with a slide valve driven from a fixed eccentric on the crankshaft within the bed, and hence its cut-off is fixed. Steam distribution in the high-pressure cylinder, however, is controlled by a balanced and adjustable piston valve, which is itself actuated by the swinging eccentric of a shaft governor. In this way the fan is maintained at a uniform speed when serving one or all of the boilers without any alteration in the position of the dampers. The feature of tightly enclosing the engine will be appreciated when the environment in which the engine operates is recalled.

New Trade Catalogues

THE machinery trades need scarcely be told what the machine tool catalogue is which Messrs. Manning, Maxwell & Moore, of New York, have issued for a number of years past. It has always been one of the marvels among trade catalogues; indeed, trade catalogue is a term which scarcely fits it, since it may properly be said to be the most comprehensive collection of information regarding machine tools that has ever been published anywhere. The new edition which has just made its appearance, and which bears the date 1901, is, like all its predecessors, a mammoth volume of over 700 large sized pages, and it would be difficult to think of any kind of tool not found represented in it. There must be several thousand illustrations in the book, and each one is accompanied by descriptive particulars and tables of sizes,—in fact, just such information as the dealer and prospective purchaser want to have. A carefully prepared index forms part of the volume, and is valuable feature of it.

A NEW catalogue issued by the M. C. Bullock Manufacturing Company, of Chicago, deals with some of their latest types of hoisting machinery for all purposes. Illustrations are given, together with detailed tables of sizes and capacities.

Two of the latest catalogues issued by the B. F. Sturtevant Company, of Boston, Mass., are devoted to heating, ventilating, and moistening in textile manufactories and to their well-known steel-plate fans. Like all the Sturtevant publications, they are arranged in an attractive manner, and the information which they give is interesting and useful.

"SOMETHING ABOUT COVERINGS" is the title of a neat booklet issued by the H. W. Johns Manufacturing Company, of New York. It is devoted to the interests of their asbestos non-heat-conducting coverings for steam pipes and boilers, hot-air flues, cold water, ammonia, and brine pipes, etc. The illustrations show not only how the different kinds of coverings made by the company are applied, but give some interesting views of the works of the Standard Oil Company, at Bayonne, N. J., which were destroyed by fire last summer, but in which the boiler and pipe installations remained standing. These were covered with some of the Johns Company's preparations, and the coverings remained intact almost throughout.

A PRICE LIST of gears of all kinds has just been issued by Messrs. James & Foote, of Chicago. The subject-matter proper is supplemented by some general information on gears and handy rules and tables of different kinds.

PNEUMATIC tools form the subject of an attractive pamphlet just issued by the Cleveland Pneumatic Tool Company, of Cleveland, Ohio. The illustrations show not only the tools themselves and sectional views explaining their construction, but comprise shop views as well, showing their various applications. The pictures, in fact, are the principal part of the pamphlet, and illustrate some of the advantages of tools of this class in a very direct way.

AUTOMATIC bolt threading and tapping machines are treated of in a pamphlet brought out by the Webster & Perks Tool Company, of Springfield, Ohio. It contains illustrations and particulars of the usual kind, setting forth the principal features of the tools and stating their sizes.

THE prospective user of friction clutches will find matter of interest in a new catalogue issued by the Eastern Machinery Company, of New Haven, Conn. It is devoted to the Frisbie friction clutches and clutch pulleys, and not only gives illustrations from which their method of operation can be easily understood, but also detailed particulars and comprehensive tables of sizes, together with the power which can be transmitted by each at a given speed.

THE John A. Roebling's Sons Company, of Trenton, N. J., manufacturers of all kinds of cables and electric conductors, have received for their exhibit at the Paris Exposition two "grand prizes" and two gold medals, the highest honours within the gift of the Exposition authorities. One striking feature of the Roebling exhibit was a large model of the Brooklyn Bridge. This was an exact representation of the famous suspension bridge, and surmounted the exhibit proper. The first model of the bridge that was built for the Exposition was lost with the unfortunate *Paulliac*, which was reported near her destination six days after sailing and was never heard from afterward. The Roebling Company, however, built a second model in six weeks, and had it in its place about a month after the Exposition opened.

Manufacturing News

SOME interesting facts concerning trusts in European countries are presented in recent consular reports to the United States Government. As referred to in the New York *Tribune*, the name "trust" appears to be little used, if not unknown, but the thing itself flourishes. In Germany a trust is known as a "cartel." There is one in the sugar trade, comprising 98 per cent. of the whole. There are others in the coal, iron, tinplate, oil, soap, brick, potassium, and many other trades. Indeed, they seem to dominate practically all branches of industry. Their objects are to suppress competition, maintain prices, and, if necessary, restrict production by the partial or entire closing of works. Probably the total number of such combinations in Germany, in both the wholesale and the retail trade, is not less than three hundred. Some of these existed before the adoption of a protective tariff, in 1879, but most of them have arisen since that date. German economists attribute their multiplication, however, not to protection, but to the general industrial and commercial tendencies of the age.

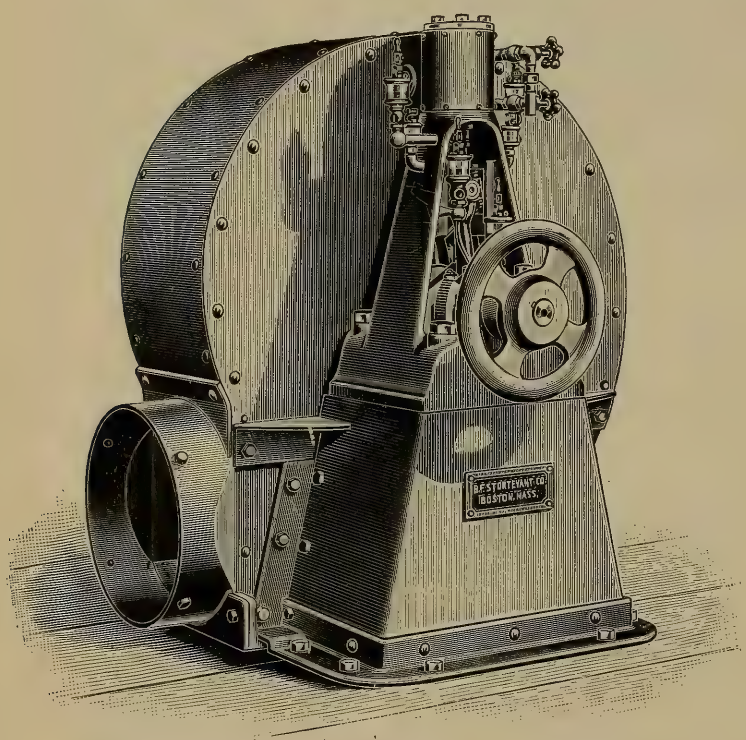
Trusts in Europe

In Austria industries are newer than in Germany and trusts are fewer, but the latter are fully as influential over conditions of production and consumption. Indeed, they are probably more offensive there than in Germany, for they have long since ceased to be a means of defense, and in most cases are nothing but a speculation for an increase of prices. The iron, coal, oil, and sugar trades are among those dominated by trusts, and the effect of such control has been seen in a 30 per cent. increase in the price of coal. A bill for the regulation of trusts,—or "cartels,"—has been drafted, but not yet enacted. In Belgium there are trusts in the coal, sugar, plate glass, and other trades. Holland is not a manufacturing, but an agricultural, fishing, and commercial country. Nevertheless the coal trade and other industries, so far as they exist, are in the hands of monopolies. Outside of the iron trade Italy appears to have few trusts. Competition among manufacturers is intense, and consequently wages are extremely low. Recently trusts or "syndicates" have been formed in the sulphur and sumac trades, with the result of a general increase of wages. Spain, too, has few trusts, excepting the monopolies granted by the government in tobacco, matches, etc.

France seems to be, of all great in-

dustrial countries, most free from trusts. Theoretically, there are none, such combinations being prohibited by law. As a matter of fact, however, the iron, petroleum, sugar, borax, and other trades are controlled by "syndicates," and the tendency of the country is unmistakably toward the multiplication of such organisations. In both Sweden and Norway avowed trusts are unknown, but understandings and agreements exist among manufacturers which amount practically to the same thing. Organisations of capital are still, however, far behind those of labour. Much the same may be said of Switzerland; there are no trusts in the American sense, but almost every trade is controlled by a combination or agreement for the regulation of production and prices. Finally, in the United Kingdom trusts flourish as nowhere else. There has been no opposition to them in either legislation or public opinion. "However," writes the United States consul at Glasgow, "one has but to go through the country and note the tall chimney stacks standing here and there, idle and alone, from which the rest of the works have been moved or razed, to understand that the combination has reduced output or confined operations to a narrower limit, and these smokeless chimneys are mute witnesses to the fact that a once flourishing enterprise has been throttled."

Such is the situation in Europe. There is just one radical difference between European and American trusts. That is found in the capitalisation, which in Europe is kept at the lowest possible figure, while here it is too often swelled with "water" to the highest possible figure. That, evidently, is an important difference. But in other respects the same law of combination operates in all parts of the industrial world. It seems to be as general as the development of combinations of labour a generation ago or less, and as logical; and it may, perhaps, best be regarded as an inevitable process in industrial evolution.



NEW STEAM FAN, BUILT BY THE B. F. STURTEVANT CO., BOSTON, MASS.

A New Sturtevant Steam Fan

THE rapid increase in the use of small, independent driven fans, which has marked the progress of the last few years, has led to the design of both motor and engine-driven fans to meet this requirement. Where electricity is not available as motive power the steam fan becomes a natural substitute.

The B. F. Sturtevant Company, of Boston, Mass., has recently brought out a line of small sizes of steam fans, of which the illustration on this page gives a good idea. These fans range in total height from 30 to 50 inches, and weigh from 350 to 950 pounds. These are designed for creating pressure of at least one ounce per square inch when the engine is operated under 80 pounds of steam, and for this purpose the engines have to be constructed to run from 650 to 1250 revolutions per minute, according to the size.

Such high speed naturally requires great care in the design and construc-

tion of the engine. Some difficulty arises from the small size of the engine itself, the minimum size of cylinder in this type being 2½ inches diameter by 2 inches stroke. In all cases, however, these engines are equipped with piston valves, with marine type connecting rods, counterbalanced crank, and complete continuous, sight-feed oiling arrangements. All moving parts are adjustable for wear, and the cylinder is lagged to reduce condensation. A hand wheel is provided for starting the fan, which latter is of the well-known Sturtevant construction, consisting of a steel-plate housing, with light and carefully balanced steel-plate wheel within. This wheel is mounted upon the extended engine shaft, and draws the air through the inlet from the farther side.

Such fans find especial use in small mechanical draught plants, where they may be operated independently of any other source of power, and find particular opportunity for service on board steam yachts and similar small vessels.

New Trade Catalogues

WITH the new year has come an avalanche of new trade catalogues, ranging from the elaborate kind, text-book-like in character, with substantial binding, to the comparatively modest pamphlet of only a few pages, all, however, answering their purpose measurably well, illustrating and describing a variety of machinery, and endeavouring to present it to prospective purchasers in the light best calculated to bring out its good points.

In its way, one of the most interesting of the present collection is that issued by Arthur Koppel, of New York. It is devoted altogether to the industrial railways made by that firm, and is printed in English, French, German, Dutch, Spanish, and Russia, giving it a distinctly cosmopolitan air. The illustrations are numerous and well executed, and are admirably suggestive of the variety of good uses which may be served by railways of the type specially considered.

Of the steamloop and the Holly gravity return system for steam plants, Messrs. Westinghouse, Church, Kerr & Co., of New York, have issued a catalogue which bears the characteristic Westinghouse imprint of artistic excellence. But it has a distinctly practical value, as well, in setting forth the details of the systems to which it is devoted. A large number of beautifully executed half-tone illustrations form part of the booklet. Another Westinghouse catalogue is devoted to the motor-driven air compressors built by the Westinghouse Air Brake Company, of Pittsburgh.

Fans and exhausters of different kinds are treated of in a catalogue brought out by the Boston Blower Company, of Hyde Park, Mass. It is profusely illustrated, and gives the usual information in the way of sizes and capacities.

The Morison Suspension furnace for marine boilers is treated of in a new catalogue which has come from the Continental Iron Works, of Brooklyn, N. Y. The various types of the furnace are illustrated very thoroughly, and the pictures are accompanied by brief particulars.

Gas furnaces for general machine shop and tool work form the subject of a catalogue brought out by the Chicago Flexible Shaft Company, of Chicago. It illustrates and describes a few of the great variety of uses to which the gas furnaces made by this firm are specially adapted. Particulars are also given of the gas generators which the makers supply for use in places where city gas is not obtainable.

The L. W. Pond Machine Company, of Worcester, Mass., in a new catalogue, illustrate and describe their planers and pulley turning and boring machines.

In the line of engines there are several catalogues, two of them coming from the Chandler & Taylor Company, of Indianapolis, Ind., devoted to both their plain slide-valve engines and their automatic engines. Both catalogues are profusely illustrated, and ought to be of good service to engine purchasers. The Ball Engine Company, of Erie, Pa.,

in their catalogue illustrate and describe, in some detail, their self-oiling engines. These, as they point out, are built from entirely new designs and patterns, and embody in all details the highest development of modern steam-engine practice. The B. F. Sturtevant Company, of Boston, have a catalogue showing their several types of vertical and horizontal engines, both automatic and throttling. Still another engine is presented in the catalogue of the American Blower Company, of Detroit, Mich. Horizontal and vertical types of this are made, and particulars are given of both.

There are three new catalogues of pumping machinery, one from the Morris Machine Works, of Baldwinsville, N. Y., another from the Epping-Carpenter Company, of Pittsburgh, Pa., and the third from the Union Steam Pump Company, of Battle Creek, Mich. The catalogue of the first mentioned firm is devoted wholly to centrifugal pumping machinery. The other two describe reciprocating pumps of various designs.

Coal-handling machinery is treated of in a new catalogue by the C. W. Hunt Company, of New York, and a large number of illustrations of its various forms are given.

An instructive and interesting little book, devoted to wire rope and its application to the transmission of power and other uses, has been brought out by the Trenton Iron Company, of Trenton, N. J. It is full of practical information.

This may be said as well of a neat little publication entitled, "Hints on Painting Structural Steel," by Houston Lowe. This title practically tells what there is in the booklet, which, apparently, has been issued by the Lowe Brothers Company, of Dayton, Ohio, makers of paints for iron and steel.

Turbine water-wheels are presented in a catalogue by the John W. Taylor Manufacturing Company, of Mount Holly, N. J. The Taylor turbine and its accessories are illustrated and described, and a number of pages of interesting miscellaneous information are added, such as a short chapter on the measurement of water, the discharge of water through openings under pressure, etc.

The Jeffrey Manufacturing Company, of Columbus, Ohio, have issued what they call a special sawmill catalogue, in which they give illustrations of their general line of conveying machinery for the lumber and woodworking industries.

The American Steel and Wire Company, of New York and Chicago, have brought out a small pamphlet containing a condensed presentation of the leading features of, and specifications essential in ordering, electrical conductors and other equipments for street railways, electric light and telephone systems and power circuits. It is a handy little book for electrical men.

With the development in grinding machines in modern machine-shop practice, interest is attached to the catalogue devoted to such machines, brought out by the Landis Tool Company, of Waynesboro, Pa. The machines are illustrated and described in some detail, and directions are given for their care and use.

Manufacturing News

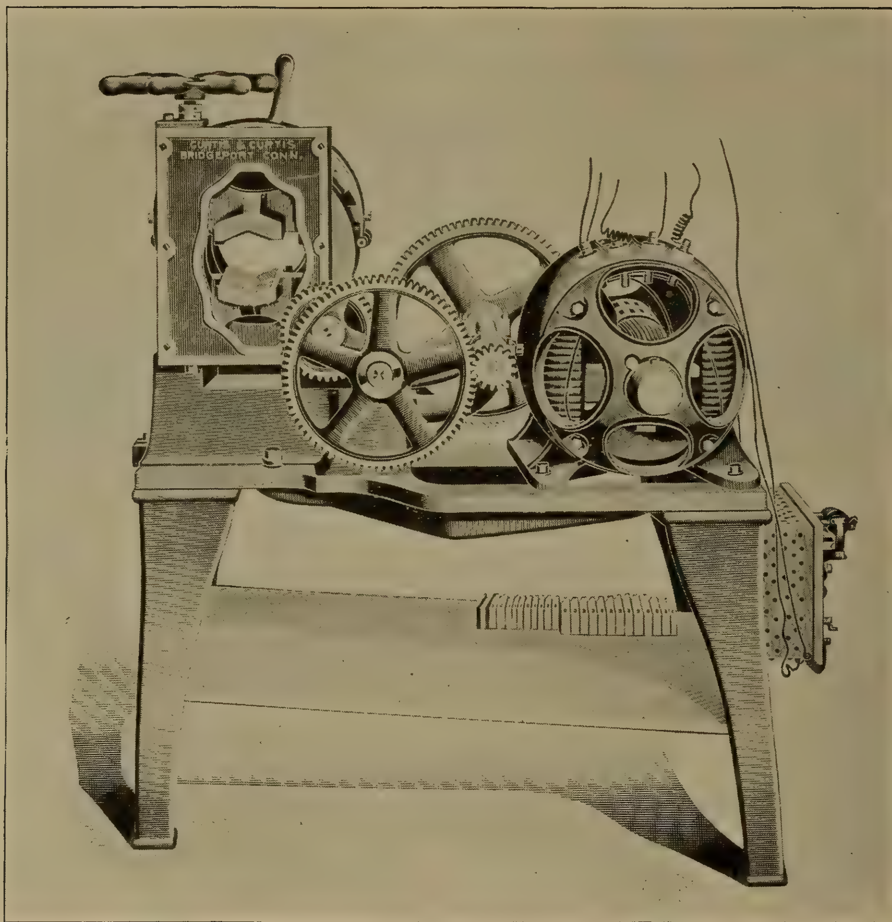
ACCORDING to data presented by the B. F. Sturtevant Company, of Boston, in their treatise on " Ventilation and Heating," the proportional heating surface in hot blast heating is generally expressed in the number of net cubic feet in the building for each lineal foot of 1-inch steam pipe in the heater. On this basis, in factory practice, with all of the air taken from out-of-doors, there are generally allowed from 100 to 150 cubic feet of space per foot of pipe, according as exhaust or live steam is used, the term " live steam " being taken in its ordinary sense as indicating steam of about 80 pounds pressure. If practically all of the air is returned from the building, these figures will be raised to about 140 as the minimum, and possibly 200 cubic feet as the maximum, per foot of pipe. Of course, the larger the building in cubic contents the less its wall and roof exposure per foot of cubic space, and consequently the less the loss of heat and the smaller the heater relatively to the cubic contents. In such buildings, used for manufacturing purposes, where the occupants are usually well scattered, an air change once in fifteen to twenty minutes represents the general practice; but in public and similar buildings this change is, of necessity, reduced to one in seven to twelve minutes. Owing to the increased loss of heat by leakage or ventilation under such conditions, and also to the demand for a slightly higher temperature than in the shop, the allowance is dropped to from 70 or 75 to 225 cubic feet of space per foot of pipe, for all of the air is taken from out-of-doors and low-pressure steam is usually employed.

Hot Blast Heating

ONE of the latest applications of electric motors to tool driving is found in the Forbes die stocks of the Curtis & Curtis Company, of Bridgeport, Conn., of which an illustration is given on the next page. These motors can be supplied for any desired voltage, and are so arranged that a varying speed can be obtained, suitable for the different speeds at which it is desired to run the pipe machine.

Electrically-Driven Die Stocks

It will be found that this equipment is very convenient when doing outside piping, as a machine and motor can be carried to the work, connected to some convenient electric current, and the work done on the spot without the work being carted to the machine. It often



ELECTRICALLY DRIVEN DIE STOCKS MADE BY THE CURTIS & CURTIS CO., BRIDGEPORT, CONN.

happens that piping has to be done in unfinished buildings, or in factories on a holiday, or during repairs to the boiler plant, when it would be impossible to get steam pressure, so that electric power would be the only available means of cutting a pipe, excepting by hand power. For these uses this equipment will be found especially serviceable.

The Curtis & Curtis Company are prepared to furnish the motors separately from the pipe machine. When supplied in this way they are belted from the motor to the countershaft, and from the countershaft down to the pipe machine. While not so convenient, when arranged this way, for carrying the machine from place to place, as the countershaft would have to be taken down and put up again, it has the advantage for small shops that other machinery besides the pipe machine could be run from the motor. The makers are prepared to furnish these motors from 1 to 15 horse-power, and arranged for 115 230 or 500 volts.

Clayton Air Compressors

MANY of the latest uses of compressed air, together with improvements in older methods, especially in the pneumatic tool field, have necessitated efficient air compressors suitable for higher working air pressures. To meet these requirements compressors with the air end compound (one, three, four, and often five-stage) have been devised. While this subject has had most careful and intelligent study on the part of the leading manufacturers of air compressors for a number of years, it has only been during the past two years that the demand for this class of machinery has become such an important factor in the compressor output.

Many devices have been invented for

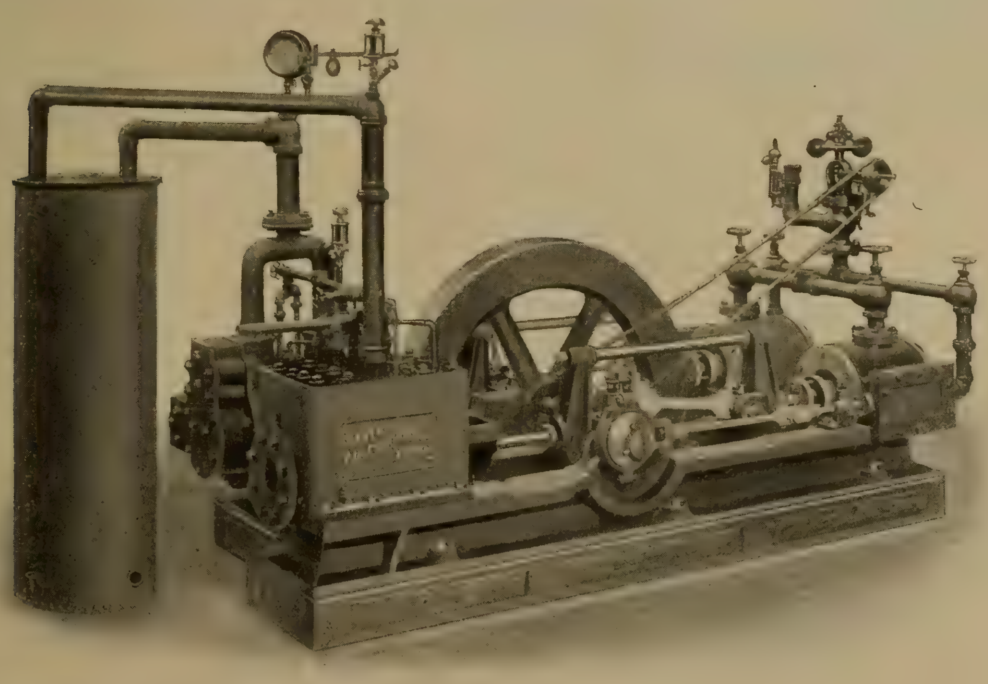
the cooling of air during compression in single-stage machines, but as yet none have approached perfection. The method generally adopted has been the water-jacketing of the air cylinders and heads. Therefore, when a constant working air pressure of 100 pounds or more is required, compound compressors are recommended. Compounding accomplishes several objects, such as a more equal division of strains, resulting in greater economy of power consumption and maintenance, and a gain of surface cooling, resulting in higher efficiency.

The illustration on this page shows a two stage compound air compressor, built by the Clayton Air Compressor Works, of New York City, which embodies all of the latest improvements and at the same time retains that simplicity of design and accessibility of working parts for which the Clayton duplex type has become so well known. If necessary, the machine can be operated without the intercooler. These intercoolers are built either open or enclosed. For ordinary use the open intercooler is preferable. The compressors are built with patent "safety" inlet and high-pressure discharge valves, patent water circulating arrangement, speed or pressure governors, or both combined, as may be desired, sight-feed lubricators, glass oil cups, wrenches, and all other mountings complete. The machines are also built in two, three, four or five-stage designs, as may be required.

A New Desk Telephone

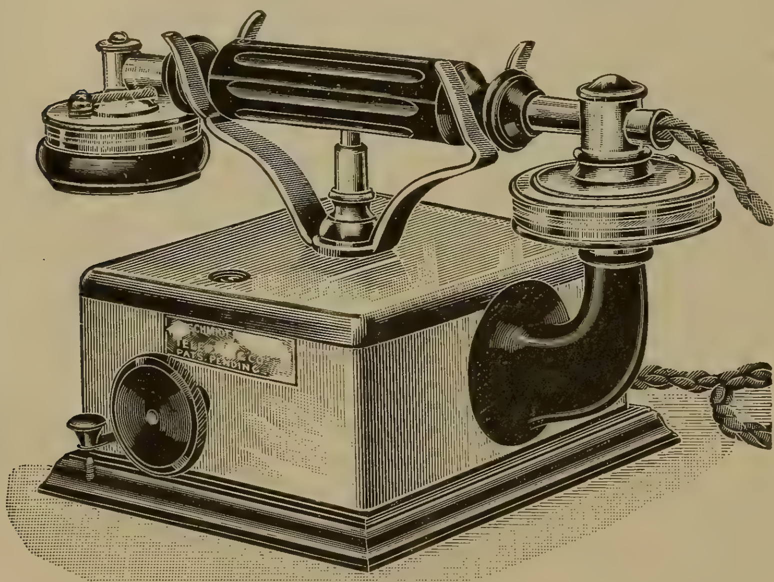
ONE of the telephone specialties brought out by the Lambert-Schmidt Telephone Manufacturing Company, of New York City, is the automatic intercommunicating desk telephone shown in the accompanying illustration. The set consists of a base on which is mounted the switching device, and over this base is fastened a nickel-plated brass cover. On the top of the cover is a metal support with a fork at each end, and in the centre of the support, at its intersection with the cover, is set a small perpendicular tube with a long, projecting hard-rubber button extending inside the cover. The transmitter and receiver are embodied in the micro-telephone and connected to the stand by a long, silk-wrapped cord. Normally the micro-telephone is laid across the support.

To connect with another telephone in



TWO STAGE AIR COMPRESSOR, BUILT BY THE CLAYTON AIR COMPRESSOR WORKS, NEW YORK

the system, the micro-telephone is removed from the support and the finger knob at the side is turned, revolving a steel centre shaft. On this shaft are arranged a set of pins projecting at different degrees, and, at regular intervals, these pins wipe against stationary springs fastened to a rack on each side of the shaft. As the micro-telephone is removed from the support the button in the centre tube rises, which lets fall a clutch on a cog-wheel at the end of the shaft, this clutch holding the shaft at each arc of the pins. On the shaft is an aluminium wheel with a numbering strip bound similar to a wheel tire, this strip being divided into sections corresponding with the arcs described by the pins. Directly over this wheel a hole is cut through the metal cover, protected by glass, and the numbers on the wheels are seen as the shaft revolves. Thus, when pin No. 5i s brought in contact with Spring No. 5, this number shows through the glass. The springs on the rack are of phosphor-bronze, and each is connected to a different telephone in the system. The signalling device is a push button at the side of the cover. When the micro-telephone is replaced on the support it presses down the long hard-rubber button in the tube, which releases the clutch from the cog-wheel, and the shaft is revolved to its normal position by a reversing spring. The rising of this long button also cuts in the talking and cuts out the bell circuit, and the reverse when pressed downward. The cover is removed from the base by the withdrawal of two small screws set in the upright guides on the base.



A NEW DESK TELEPHONE MADE BY THE LAMBERT-SCHMIDT TELEPHONE MFG. CO., NEW YORK

To operate the outfit, remove the micro-telephone from the support; turn the finger knob to the number desired, this number showing through the glass; press the ringing button; talk; and, when through, lay the micro-telephone across the support. The switch then immediatel yrestores everything to normal position, ready for a call. If a wrong number is called by mistake, restore the switch and call as before.

Apropos of the short article entitled, "Reducing the Cost of Machine Work," which appeared in the February number of this magazine, it is interesting to refer to an attractive little catalogue brought out by the H. W. Franklin Manufacturing Company, of Syracuse, N. Y., which tells a good deal of interest about finished parts made by a process of casting which avoids machine work. Illustrations and text are alike interesting, and will appeal to all who may see this little pamphlet.

Those interested in acetylene lighting will find some things worth reading in a little pamphlet on acetylene generation just brought out by F. Cortez Wilson & Co., of Chicago. It is entitled, "The Kernel of the Subject," and will be found to present it in a readable manner.

Manufacturing News

THE rapidly growing use of polyphase current in power plants of great size is creating a demand for transformers of a larger capacity than have ever before been designed, and it is interesting, therefore, to note that the Westinghouse Electric & Manufacturing Company, of Pittsburgh, recently began on what is said to be the largest single order for transformers ever recorded. It comprises twenty 2750-KW transformers of the Westinghouse air blast type. Each of these, with an output of over 3600 H. P. of electrical energy, weighs, approximately, eleven tons, and stands 9 feet high. Of the twenty units, ten are used to raise the voltage from 2200 to 25,000 volts at 8000 alternations. The input is two-phase and the output three-phase. The remaining ten transformers, for lowering the voltage, receive the three-phase line current at 22,000 volts and deliver a two-phase current at 2400 or 4800 volts, as required.

Large Electric Transformers

The blowers for furnishing the air blast for cooling both the raising and lowering transformers are operated by Westinghouse induction motors. The well-known Westinghouse methods of construction are employed in these transformers, both primary and secondary being divided into several flat coils wound with many layers, and few turns per layer, each coil being insulated separately. The advantages of this construction are that it divides the total E. M. F. between the several coils, reducing proportionately the strain of each individual coil; also, it divides the E. M. F. in a single coil between many layers, thus reducing the potential between the adjacent layers. The regulation of the transformers is also improved, and the windings may be connected easily in series or multiple, thus giving a wide range of E. M. F. Also, in case of damage to a coil, a substitute may be provided with but little trouble, and without sending the transformer to the works.

Iron and copper have been carefully proportioned to secure the minimum losses, and the efficiency of the transformers is very high, being considerably over 98 per cent. It is, however, not sufficient that the loss in a transformer be low when it is first installed; for, as is generally known, much of the iron, that has been used in transformers when subjected to the conditions pre-

vailing in continued service, is subject to a material deterioration, more or less rapid, with the result of a corresponding material increase in the iron losses. In some cases this increase has amounted to a doubling of the loss found in the transformer when first installed.

With careful and systematic study of the subject, however, there has been established a special process for the manufacture and treatment of transformer iron yielding an iron at once capable of high magnetisation with comparatively little energy, and having a stable character completely resisting the tendency to deteriorate in service with consequently increased losses.

A peculiar feature of these large transformers is the change effected in them from two to three-phase and from three to two-phase current, the change being secured by means of special windings, invented by C. F. Scott, of the Westinghouse Company. This greatly increases the flexibility of two and three-phase methods of transmission.

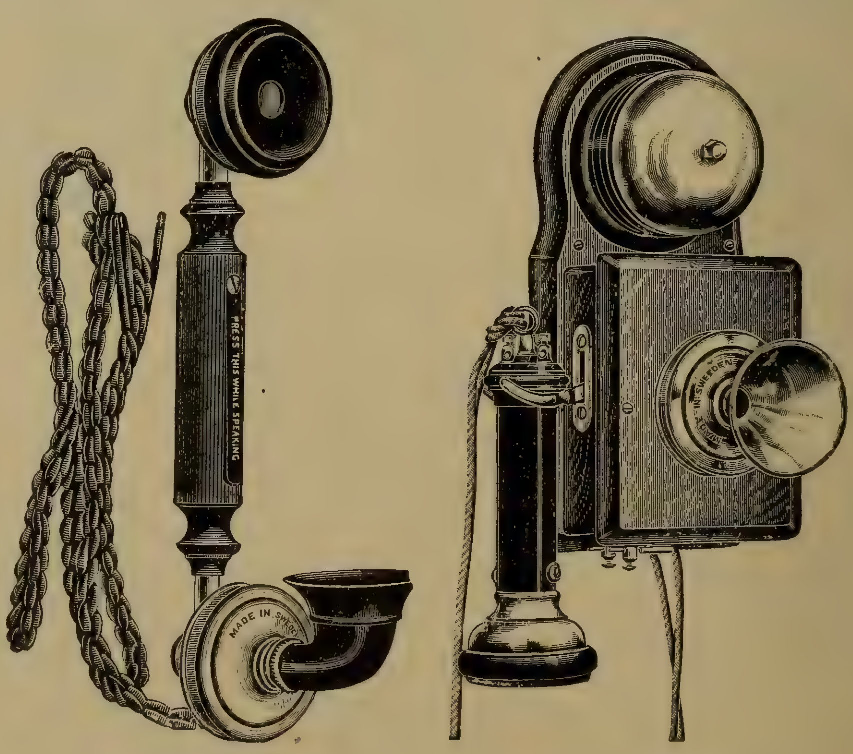
Shop and Factory Telephones

As time and money savers in shop and factory, telephones have become important equipment accessories. It seems worth while, therefore, to direct attention to the special telephone outfits put on the market by the Ericsson Telephone Company, of New York, and which are sold outright and not rented. Two varieties of their instruments are shown on this page, one of them representing the long watch-case receiver and transmitter, and the other, the combined eceiver and transmitter. For large systems, where a number of telephones are required, the makers arrange for placing all batteries together and to call automatically by taking the receiver from the hook. Also, if desired, they supply magneto instruments for calling in the usual manner by turning a crank, either for intercommunicating use or with central switchboard.

The systems supplied by this company are in use in many shops and factories, hotels, offices and exchanges, and they furnish the instruments and adapt the system to any requirements and for any use desired.

The Sturtevant Eight-Pole Electric Motor

THE B. F. Sturtevant Company, of Boston, Mass., has been developing the electric fan along various lines during the past few years, and, as an outcome, has produced a type of eight-pole motor, illustrated on the next page, which may be either attached directly to the fan side, or, as shown, supported upon feet and used as an independent machine.



COMBINED RECEIVER AND TRANSMITTER — WATCH-CASE RECEIVER AND TRANSMITTER

MADE BY THE ERICSSON TELEPHONE COMPANY, NEW YORK

The field ring, which also constitutes the frame, is of wrought iron in the small sizes, of cast steel in the medium, and of cast iron in the large size. The field cores are of wrought iron, and the pole shoes of cast iron, of such peculiar shape and size as to render these machines capable of meeting extreme variations of load without sparking or the necessity of adjustment.

EIGHT-POLE ELECTRIC MOTOR BUILT BY THE B. F. STURTEVANT COMPANY, BOSTON, MASS.

The field coils are machine wound, thoroughly insulated, and of such open construction as to secure the maximum radiation and ventilation. The armature core is built up of laminated, slotted discs, which are solidly clamped between two brass rings having corresponding slots. The coils are machine wound, of uniform size and shape, and thoroughly insulated, the armature being of the drum type. The commutator is of large diameter, the segments being of fine drop-forged copper. For high voltages or small outputs at low speeds, two sets of reaction carbon brushes are usually employed, and, from the character of the design, require no adjustment. Tripod bearing yokes are provided, as shown, except in the largest machines, which are equipped with special bases and pedestal bearings. The shaft runs in gun-metal sleeves, and is lubricated by means of ring oilers.

In this style these motors are built in powers ranging from 3 to 37½ H. P. at normal speed. In larger sizes a pedestal base is provided, giving the motor a still more substantial character. In all sizes these machines are built both as motors and generators.

ONE of the most interesting catalogues of the month, if indeed it can be so termed, is a little pamphlet

New Trade Catalogues

brought out by the Westinghouse Machine Company, of Pittsburgh, devoted to steam turbines. It is, in fact, a paper on the subject presented a short time ago to the Engineers' Society of Western Pennsylvania by Francis Hodgkinson. While the subject of steam turbines is taken up in it in a general way, it contains specific reference also to the Westinghouse-Parsons turbines, and accompanying the text are a number of interesting illustrations in the shape of photographic reproductions and diagrams, all of which help to make the little book a most interesting one.

Mechanical draught is discussed in an attractive pamphlet brought out by the American Blower Company, of Detroit, Mich. The aim of the publication is to point out the advantages of mechanical draught in a clear and simple manner, so as to be easily understood by anyone interested in the subject. A large number of finely executed half-tone illustrations accompany the reading matter.

Four little books, in one batch, have come from the Buffalo Forge Company, of Buffalo, N. Y. They, too, are devoted to mechanical forced draught, mechanical induced draught, down-draught forges, and automatic steam engines. All of them are profusely and attractively illustrated.

Heating and ventilating the largest round-house in the world form the subject of a pamphlet from the B. F. Sturtevant Company, of Boston. The round-house in question is that of the Chicago & Northwestern Railway, at Clinton, Ia., and the particulars given in the little pamphlet explain the general features of the system adopted in a direct and an interesting manner.

Messrs. Fraser & Chalmers, of Chicago, have brought out a new engine and boiler catalogue which is full of useful information. The engines considered comprise ordinary slide-valve designs, single-valve automatic engines, and horizontal and vertical Corliss designs, running up to very large sizes. Among the boilers there are various types, all of them illustrated and described in some detail. Air and circulating pumps, jet condensers, steam separators and receivers, and also feed-water heaters and injectors all receive attention.

The H. W. Johns Manufacturing Company are out with two little books, one devoted to what is known as the "Lustral" finishes for woodwork, a species of varnish, and the other is entitled, "Suggestions for Exterior Decoration." This sufficiently indicates its scope. Paints, of course, are the subject matter under discussion.

In the line of gas and gasoline engines there is a new catalogue by the New Era Iron Works Company, of Dayton, Ohio. The illustrations in it are finely executed, and the information, as a whole, is of interest to users of gas or gasoline engine power.

Air compressors are discussed in a new catalogue by the Clayton Air Compressor Works, of New York City. The company make air compressors of every type for all pressures and for every purpose to which compressed air is applied, and the catalogue gives the kind of information which the prospective purchasers of this kind of machinery is most likely to want. An interesting adjunct to the catalogue is a short section devoted to compressed air specialties, such as pneumatic drills, riveters, hammers, air hoists, compressed air nozzles for cleaning furniture and machinery, compressed air fuel oil burners, and others.

Another air compressor catalogue is that of the Ingersoll-Sergeant Drill Company, of New York. It is a very attractively gotten-up publication, and contains a mass of useful compressed air information,—flow of air through pipes, air required for operating hoisting engines, rock drills, coal cutters, and other machinery, tables of efficiencies for different altitudes, horse-power necessary to compress air to different pressures, etc. In some measure, therefore, the catalogue is really a little text-book on compressed air engineering.